THE EDITOR'S PAGE

Showdown

The battle between materials (temporarily suspended due to Korea) is reduced to its simplest terms in Pittsburgh. Facing each other, in the heart of the Golden Triangle, will be the new Mellon Building and the Alcoa Building. The former will house all of the Pittsburgh offices of U. S. Steel Corp. and its subsidiaries; the latter is to be home of Aluminum Co. of America. Naturally, the Mellon Building, which has a head start of six months, glistens with steel of all kinds with a liberal sprinkling of stainless. Fencing surrounding the foundation excavations for the Alcoa Building is, naturally enough, corrugated aluminum sheet. The completion of these two brilliant buildings should do much to brighten downtown Pittsburgh.

Several generations hence we might have the answer to the comparative lasting qualities of the two metals.

Incongruity

Perhaps we are unkind to mention this, but when we gave in to the universal urge to watch excavating work for the Alcoa Building, we saw something that should be reported. A workman was busily painting the wood shoring and other surfaces with aluminum paint. Under the circumstances, it seemed somewhat out of keeping with the spirit of things to see that the aluminum paint was carried in a galvanized steel pail.

Action

We have been informed recently that MATERIALS & METHODS really spurs its reader to action. This brief report is on the long distance variety of action. Last winter M & M published an article on metal spinning by Roland E. Teiner Co. A reprint of the article eventually reached Mr. Cyril L. S. Fraser, director of a metal spinning plant in Shakespeare's home town — Stratford-on-Avon, England. Mr. Fraser was so impressed that he phoned the U. S. to arrange a visit and exchange information on spinning. We could spin more tales of this kind, but we think you'll get the point.

Perils

Usually the task of being an editor is not considered hazardous. However, it would have been difficult to convince Ken Rose, our Midwestern operative, of that a few weeks ago. Ken, always on the alert for the latest materials information, recently tracked a story to its lair. When Ken, in his usual low-pressure but never-the-less direct manner, asked the caged lion what he could expect to learn, the answer was direct, clear, concise and explosive. "Nothing," he was told, with a shout that almost drove him from the building.

A Pet Peeve

There has been established in this country a rather healthy army of so-called public relations men by many moderate to good-sized companies. Unfortunately for their companies, and for editors who must contact them, many of these men become awed with their own importance and foil rather than foster good public relations. I don't frown on the public relations profession, because there are several who cooperate with the press effectively and others who are downright helpful. But imagine the feeling one gets when he climbs from a hot, uncomfortable public conveyance, waits interminably in an impersonal waiting room and, when he finally reaches the mighty person, he is turned down on a request for help. In some such instances I've had the uncomfortable feeling that the p.a. mentally wrung his hands in glee because he had diverted another member of the press.

Added Service

If there is any one who doubts the importance and scope of materials engineering, he should visit the materials engineering department of Westinghouse at East Pittsburgh. Then, when he is thoroughly awed with the number of engineers, the variety of laboratories and the kind of work the department does, he should be further impressed with the fact that every Westinghouse plant has its own materials engineering group.

Research

Alfred P. Sloan, Jr. has given to M.I.T. a gift of $1,000,000 with which to build a metal processing laboratory. The facilities of the building will be devoted to education and research in metallurgical science as applied to basic manufacturing processes. Mr. Sloan, as you must know, is board chairman of General Motors and a great backer of M.I.T. In addition to a foundry and welding laboratory, the new building will provide space for powder metallurgy research and metal cutting studies.

T. C. Du Mond
Editor

News Digest

Extremely Thin Magnetic Strip Developed for Electronic Devices

Special magnetic alloys can now be produced in strips so thin that it takes ten layers to equal the thickness of a human hair. The 0.00025-in. strip is a development of the Research Laboratory of Armco Steel Corp.

Need for such material has resulted from the development of high-frequency electronic equipment. Electronic devices which must operate at high rates of speed require components having split-second magnetization characteristics, and only extremely thin electrical steels can reach magnetic saturation in such a short time.

Although the original goal was strip not more than 0.00025 in. thick, steels have actually been rolled to a thickness of 0.00015 in. on the tiny experimental mill. Materials rolled o far include magnetic alloys of high nickel content and 3% silicon iron. The present small-scale operation has proved that the thin strip can be produced, and has provided customers with experimental lots with which to develop faster and more efficient electronic equipment.

A typical production run starts with cold reduction of the alloy on a larger mill to obtain a thickness somewhere between 0.006 and 0.002 in. The foot-wide metal is then cut into 2-in. wide strips. Successive passes through special 5/16-in. dia. rolls produce the required thickness reduction and elongate the material some 400 times.

For testing purposes, the strip is slit into ribbons 0.10 in. wide on a jig which uses razor blades for cutters. The ribbons are then coated, wound into tiny coils and annealed. A recent order for four test coils of this ribbon weighed so little that 2250 such orders would yield only 1 lb. of metal. This order was shipped in an aspirin box.

New Metal Standards Added

A circular describing 12 new spectrographic standards which have been added to its list of analyzed standard samples can be obtained free of charge from the National Bureau of Standards, Washington 25, D. C.

Two of the standards are steel and ten are metallic tin. The booklet is a supplement to NBS Circular C-398.

Western Metal Show Scheduled

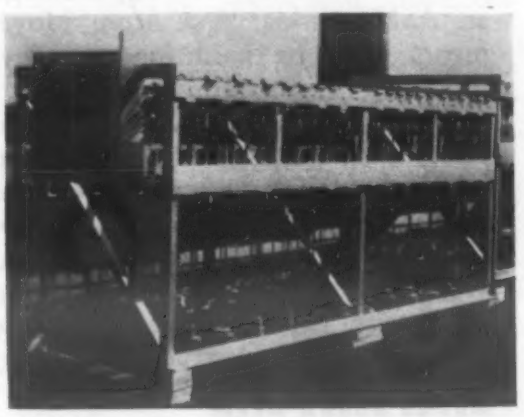
The 1951 Western Metal Congress and Exposition will be held Mar. 19 to 23, 1951 in the Oakland, Calif. Civic Auditoriums.

Manager of the seventh Western Metal Show will be William H. Eisenman, national secretary of the American Society for Metals, sponsor of the event. The Congress will be co-sponsored by some 20 technical societies concerned with oil, chemical, aviation, manufacturing, mining and other Western industries. Harry Lewis, chairman of the Golden Gate chapter of the ASM, will head the general committee.

Stress-Corrosion Resistance of Magnesium Alloys Studied

Results of an extensive investigation of the stress-corrosion resistance of magnesium alloys have been published in the *Journal of Research* of the National Bureau of Standards (Vol. 44, 1950, p. 233, Paper No. RP2074), by Hugh L. Logan and Harold Hessing, Jr.

Both sheet and extruded alloys were



These stress-corrosion racks were used in the recent NBS investigation of magnesium alloys.

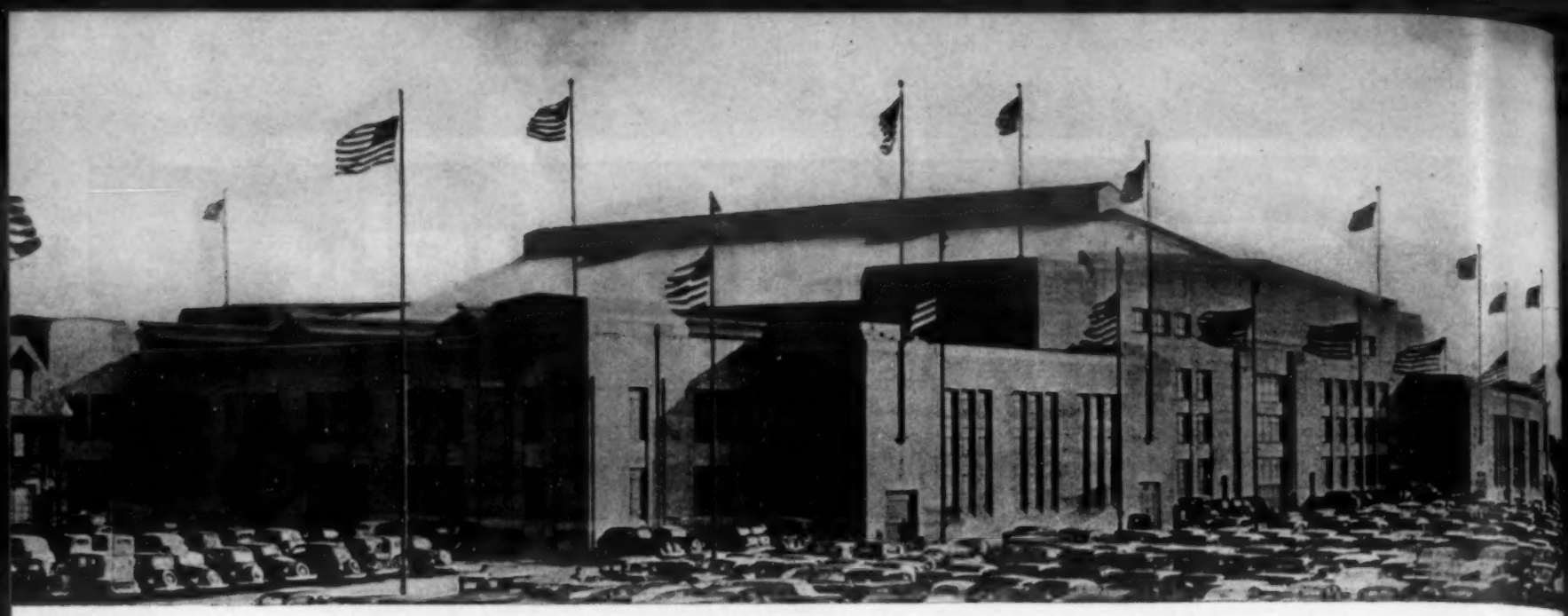
tested. Sheet materials were M1, AZ31X, AZ51X and AZ61X alloys and a clad alloy in which a core of AZ31X sheet was sandwiched between two thin layers of M1. Extrusions studied were ZK60, AZ61X, AZ80X and AZ80X-HTA.

Two Weathering Spots

Specimens were exposed to the weather stressed in tension at the Bureau in Washington and in a marine atmosphere at Hampton Roads, Va. Unstressed specimens were subjected to the same corrosive conditions in order that the effect of stress in increasing corrosion damage could be evaluated.

In general, it was found that susceptibility of magnesium alloys to stress corrosion in the weather in-

(Continued on page 142)



International Amphitheatre in Chicago will be the focal point for the 1950 Metal Show this month.

High Production Is Theme of 1950 Metal Show

The metal industries' biggest annual show, the National Metal Congress and Exposition, will be held this month in Chicago. The Metal Show, as it is more generally known, will get underway Oct. 23, although an ASM seminar on "Atom Movements" will be held for two days preceding the opening.

As has been the case in recent years, the Congress will be sponsored jointly by the American Society for Metals, the American Welding Society, the Institute of Metals Division of the American Institute of Mining & Metallurgical Engineers, and the Society for Non-Destructive Testing.

Movies Shown Again

This year the Metal Show will stress "Materials and Equipment for High Production." Success of the "Economy Theatre" presentation during last year's Show in Cleveland has led to a repeat performance this fall. As a result, visitors will get a chance to see industrial motion pictures depicting techniques and methods which contribute to high productivity in plant operations.

The annual exposition is expected to attract about 350 exhibitors of products and services for the metalworking industries. Both the exposition and the industrial films will be staged in the International Amphitheatre. Also on view there will be entries in the fifth annual metallographic exhibit sponsored by ASM.

Technical Sessions

Technical sessions of the ASM and AWS will be held throughout the week. All ASM sessions will be held in the Palmer House, while AWS papers will be presented at the Hotel Sherman. The technical program of the AIME will start Monday, Oct. 21, and continue through Wednesday at the Hotel Sheraton. A similar three-day meeting is scheduled by the Society for Non-Destructive Testing at the Hotel Morrison.

In addition, six educational sessions have been planned by the ASM and AWS. A schedule of these meetings appears on this page. A correlated program of both technical and educational sessions is given on the next page.

The ASM annual meeting will be held Wednesday morning, Oct. 25. At that time the Edward de Mille Campbell Memorial Lecture will be delivered by Earle C. Smith, Chief Metallurgist, Republic Steel Corp. The Saveur Achievement Award, established by the ASM in 1934, will be presented to Clarence E. Sims, Assistant Director, Battelle Memorial Institute, for "his pioneering studies and sound research into the origins and effects of inclusions in cast steels."

Other Meetings Scheduled

The regular technical sessions of the AIME will be supplemented by an informal panel discussion on Precipitation Hardening Monday evening. Morris Cohen, of MIT, will act as moderator of a nine-member group.

Two special sessions will be presented by the AWS. One is a panel discussion on Recommended Practices for Resistance Welding, scheduled for Monday afternoon. Chairman will be J. Henschkel, of Westinghouse Electric Corp. The other is a symposium on Applied Welding Engineering, to be held Tuesday evening with C. D. Evans, of the AWS, acting as chairman.

Educational Lectures

ASM	High Temperature Properties of Metals	Monday—4:15 p.m. and 8:00 p.m.
AWS	Welding of Aluminum	Monday—4:30 p.m.
ASM	Interpretation of Tests and Correlation with Service	Tuesday—4:15 p.m. and 8:00 p.m.
AWS	Welding of Copper	Tuesday—4:30 p.m.
ASM	Metallurgy of Titanium	Wednesday—4:15 p.m. and 8:00 p.m.
AWS	Welding of Nickel	Wednesday—4:30 p.m.

(ASM Lectures at the Palmer House—AWS Lectures at the Hotel Sherman)

Correlated Program of Technical and Educational Sessions

National Metal Congress, Chicago, October 21-27, 1950

Saturday, October 21

.M. 30	ASM	Seminar on Atom Movements, Palmer House
.M. 00	ASM	Seminar on Atom Movements (continued), Palmer House

Sunday, October 22

A.M. 30	ASM	Seminar on Atom Movements (continued) Palmer House
A.M. 00	ASM	Seminar on Atom Movements (continued), Palmer House

Monday, October 23

A.M. 00	AIME	Plastic Deformation, Hotel Sheraton
30	ASM	Surface Phenomena, Palmer House
	AWS	Weldability, Hotel Sherman
	AWS	Resistance Welding, Hotel Sherman
	AWS	Surfacing, Hotel Sherman
M. 00	ASM	Physical Metallurgy, Palmer House
	AIME	Recrystallization and Annealing Textures, Hotel Sheraton
	AIME	Structure of Alloys, Hotel Sheraton
	AWS	Flame Hardening, Hotel Sherman
	AWS	Arcs, Electrodes and Fluxes, Hotel Sherman
	AWS	Research, Hotel Sherman
	AWS	Panel on Recommended Practices for Resistance Welding, Hotel Sherman
15	ASM	Educational Lectures on High Temperature Properties of Metals, Palmer House
30	AWS	Educational Lecture on Welding of Aluminum, Hotel Sherman
30	AIME	Panel on Precipitation Hardening, Hotel Sheraton
00	ASM	Educational Lectures on High Temperature Properties of Metals (continued), Palmer House
	AWS	Adams Lecture on Dynamic Characteristics of D.C. Welding Machines, Hotel Sherman

Tuesday, October 24

A.M. 9:00	AIME	Transformations, Hotel Sheraton
	AIME	Properties of Alloys, Hotel Sheraton
9:30	ASM	High Temperature Metallurgy, Palmer House
	AWS	Pipe Fabrication, Hotel Sherman
	AWS	Resistance Welding (continued), Hotel Sherman
	AWS	Ship Structure, Hotel Sherman
	SNDT	Inspection of Nonferrous Castings, Hotel Morrison
P.M. 2:00	ASM	High Temperature Metallurgy (continued), Palmer House
	AIME	Metal-Gas Reactions, Hotel Sheraton
	AIME	Solidification, Thermal Expansion and Ductility, Hotel Sheraton
	AWS	Resistance Welding (continued), Hotel Sherman
	AWS	Design, Hotel Sherman
	AWS	Ship Structure (continued), Hotel Sherman
	SNDT	Magnetic Particle Testing, Hotel Morrison
4:15	ASM	Educational Lectures on Interpretation of Tests and Correlation with Service, Palmer House
4:30	AWS	Educational Lecture on Welding of Copper, Hotel Sherman
8:00	ASM	Educational Lectures on Interpretation of Tests and Correlation with service (continued), Palmer House
	AWS	Symposium on Applied Welding Engineering, Hotel Sherman
	SNDT	Symposium on Radio-Isotopes, Hotel Morrison

Wednesday, October 25

A.M. 9:30	ASM	Edward De Mille Campbell Memorial Lecture, Palmer House
	AWS	Symposium on Need of Professional Training for Welding Engineer, Hotel Sherman
	AWS	Structural Welding, Hotel Sherman
	AWS	Research (continued), Hotel Sherman
P.M. 2:00	ASM	Heat Treatment, Palmer House
	AIME	Research in Progress, Hotel Sheraton
	AIME	Powder Metallurgy, Hotel Sheraton
	AWS	Machinery and Maintenance, Hotel Sherman
	AWS	Controls and Standards Hotel Sherman
	AWS	Machine Welding, Hotel Sherman
	SNDT	General Session (Management and Non-Destructive Testing, High Frequency Vibration Testing, Ultrasonic Methods, Foreign Developments), Hotel Morrison
4:15	ASM	Educational Lectures on Metallurgy of Titanium, Palmer House
4:30	AWS	Educational Lecture on Welding of Nickel, Hotel Sherman
8:00	ASM	Educational Lectures on Metallurgy of Titanium (continued), Palmer House
	SNDT	Symposium on Ultrasonics, Hotel Morrison

Thursday, October 26

A.M. 9:30	ASM	Fracture, Palmer House
	ASM	Constitution of Alloys, Palmer House
	AWS	Nonferrous Metals, Hotel Sherman
	AWS	Pressure Vessels, Hotel Sherman
	AWS	Aircraft, Hotel Sherman
	SNDT	Industrial Applications of High-Voltage Rays, Hotel Morrison
P.M. 2:00	ASM	Fracture (continued), Palmer House
	SNDT	Mehl Honor Lecture on New Developments in Xeroradiography, Hotel Morrison

Friday, October 27

A.M. 9:30	ASM	Plasticity, Palmer House
	ASM	Physical Metallurgy, Palmer House
	AWS	Inert-Gas Metal-Arc Welding, Hotel Sherman
	AWS	Oxygen Cutting, Hotel Sherman
	AWS	Locomotives and Railroads, Hotel Sherman

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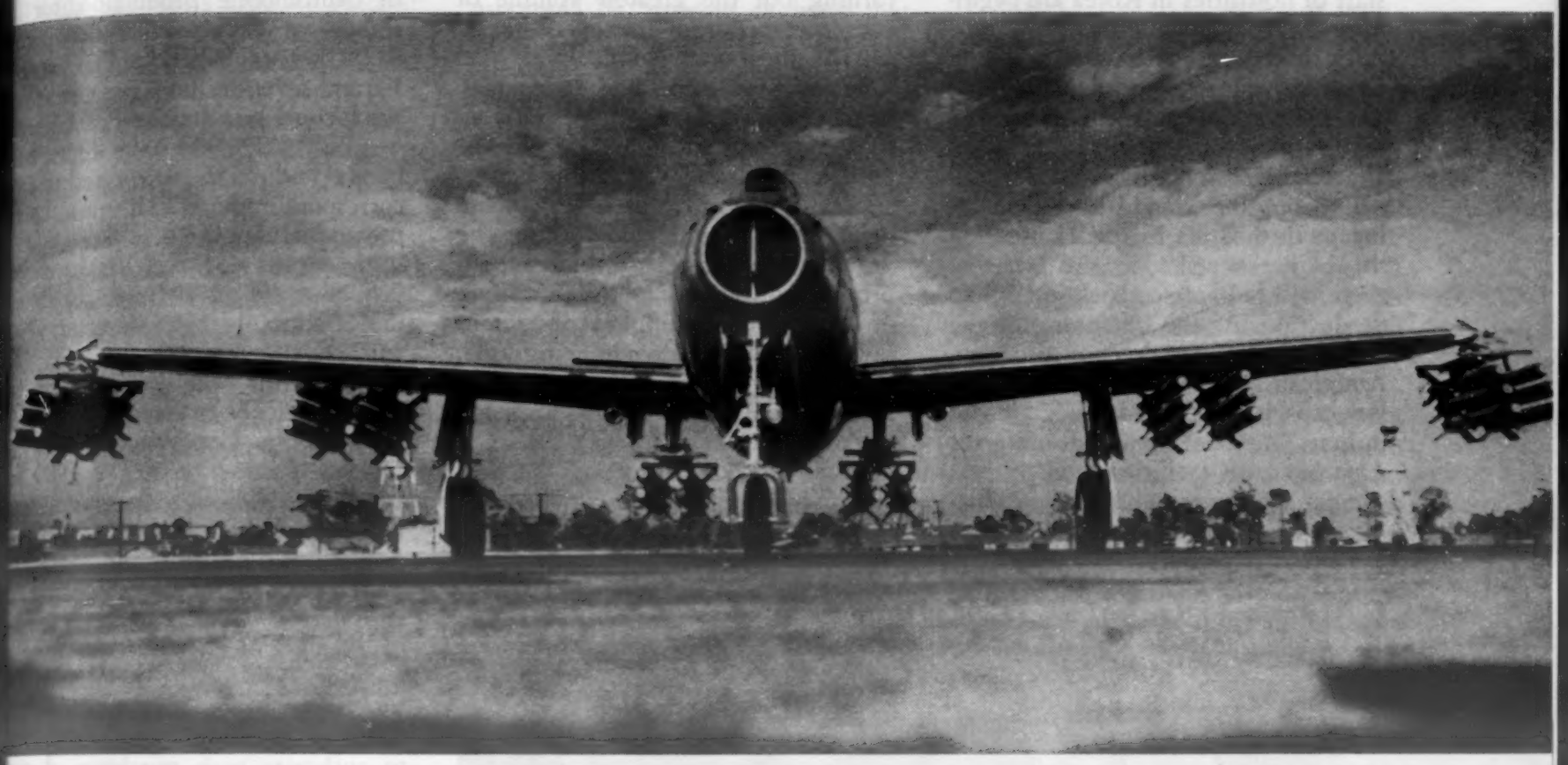


Ever-increasing numbers of speedy jet planes will require substantial quantities of high strength, heat and corrosion resistant alloys containing elements such as columbium, chromium, titanium, nickel and molybdenum, some of which are already in short supply. (Courtesy Republic Aircraft Corp.)

How Defense Production Will Affect Materials Supplies

by LEON M. JAROFF, Assistant Editor, Materials & Methods

Here is an up-to-date, concise review of the current materials picture and some conjectures on what we can expect in the event of an all-out war effort.

•AN AIR OF OPTIMISM has begun to brighten the gloomy materials picture painted by industry spokesmen immediately after the outbreak of the Korean war. With the initial wave of panic buying almost subsided, defense orders beginning to trickle in, and the mobilization program more clearly defined, these same authorities now predict that, although we are entering a period similar to the "armed camp" years of 1940 and 1941, civilian production will be far less seriously curtailed by materials shortages than it was before Pearl Harbor.

To lend weight to their revised outlook, the spokesmen point to the following encouraging factors:

1. Many items vital to our national defense which would ordinarily have to be produced are already available—left over from World War II. Thousands of ships and planes (although the latter are rapidly becoming outmoded), miles of pipeline, and hundreds of factories and bases can be made available to the defense effort on short notice, releasing great amounts of strategic raw materials for other purposes.

2. Stockpiling of strategic materials has progressed to a much greater extent than it did before Pearl Harbor, although a Bureau of Mines official admitted several months ago that, for some critical materials, it still had "a long way to go." There has been some agitation for the Government to begin releasing material from its stockpile for armaments production, but no action has been taken as yet.

3. New methods for extracting both primary and secondary materials and the experience gained in World War II in the production of National Emergency alloys can be utilized, if necessary, for increasing the supplies of strategic materials and making these supplies go further.

4. The schedule for mobilization is less accelerated now than it was before Pearl Harbor. This will give industry more time to expand and to develop sources of material for military requirements, allowing much of the existing capacity and materials

output to be used for civilian production.

5. Some of the "shortages" of materials which developed only after the start of hostilities in Korea are beginning to ease off slightly. This indicates that scare buying and hoarding were largely responsible, since too few military orders had been placed at the time to affect materials supplies appreciably.

On the other hand, this encouraging picture of the materials situation should not overshadow the fact that there will be *some* cutback in civilian production. At the beginning of the pre-Pearl Harbor defense program, American industry was operating below capacity. Increased production of military material required no great expansion of facilities, and it was comparatively easy, at first, for industry to provide additional material and plant space to meet demands.

Before Korea, however, most U. S. industries were operating at capacity, turning out the greatest volume of consumer goods in history. As a result of the boom, copper and steel supplies were tight, and manganese was becoming increasingly short before most Americans had heard of Seoul and Pohang. What this means, simply, is that any substantial volume of military production cannot be *added* to our present record civilian production. Because all, or almost all, of the available supplies of certain raw materials are already being used, new military production must displace civilian production to some extent.

Production of hard goods, such as automobiles, refrigerators, radios and washing machines, all of which con sume great quantities of potential wa material, will probably be affecte most as defense orders begin to ta in. Automobile production, for in stance, is expected to drop fro 8,600,000 units per year to betwee six and seven million. But the annu production rate before Pearl Harbo was only 3,000,000 units. Other hard goods production is expected to dro correspondingly, but it must be re membered that the new credit and in stallment buying restrictions should help close the gap between supply and the abnormally high demand which exists at this time.

Meanwhile, the government ha moved quickly to expand our mate rials supply. Congress, through th Defense Production Act of 1950, ha empowered the President to mak loans to private enterprises for the ex pansion of capacity or the productio of essential materials, "including th exploration, development and mining of strategic metals and materials." In addition, laws restricting Governmen purchasing of strategic materials hav been removed, allowing the Presiden to authorize such purchases at pay ments above the market price, if nec essary. This will enable the Govern ment to speed up the stockpiling o materials which, until now, were dif ficult to procure because of industry great demands. Of course, supplies o materials immediately available t civilian producers will be diminished by increased Government buying.

Although the Defense Act als gives the President power to allocat materials, it is believed that much o this task will be left in the hands o materials producers, some of whom were on a voluntary allocation basi even before the Korean war. So fa voluntary allocation is believed to be working satisfactorily, with supplie being distributed among regular cus tomers in proportion to their previous needs. Priority is being given to cus tomers with defense contracts, how ever, and all orders from new buyer are carefully screened to discourag hoarding.

All of the foregoing information i based on the assumption that the U. S will not be forced into an all-out war in the near future. It considers only the program of partial mobilization necessary under present long-rang plans for defense. In the following breakdown of strategic material however, the consequences of a total war effort and the availability of materials for implementing it have also been included.

Completion of a far-flung radar screen to guard the U. S. against possible sneak attacks and the equipment of our land, sea and air forces with electronic detection and navigation devices will consume great amounts of strategic materials. (Courtesy Westinghouse Electric Corp.)

Steel

The outbreak of fighting in Korea found the nation's steel industry operating in high gear and making plans for continued expansion. On July 1, 1950 the industry's capacity reached 100,563,500 tons of ingots and steel for casting, an increase of 1,170,700 tons during the first half of the year. Further increases in capacity planned for completion in 1952 will bring the production to more than 105,000,000 tons yearly.

This means that the U. S. is currently producing close to 18 million tons more than it was at the beginning of the pre-Pearl Harbor defense program and 11 million tons more than it was required to produce in 1944, the peak year of World War II. In the event of another all-out war, curtailment of civilian production would release an annual output of steel great enough to meet any forseeable demands.

Nevertheless, the situation in the steel industry is described as tight at present, even with only a small scattering of defense orders being processed. Of course, the greatest contributing factor to the present short supply is the unprecedented boom in such important steel outlets as the automobile (requiring 20% of the steel output) and housing industries. In addition, a new railroad freight car construction program—vital to our defense program—will require an estimated 250,000 tons of steel per month.

But scare buying appears to be making a larger dent in our steel supply than all of the direct defense orders made so far. Steel consumers, experiencing pre-allocation jitters, have made a mad scramble for all the steel they can obtain. Holders of so-called war steel orders, for instance, have been reported padding their requests for steel by 200%. As a result, steel spokesmen say, the steel industry is already doing next year's business. But now with voluntary allocation becoming widespread and scare buying beginning to subside, they add, there will be plenty of steel to support a long-range rearmament program in addition to maintaining a slightly reduced but healthy civilian production.

Aluminum

The U. S. aluminum industry is now producing primary metal at the rate of 725,000 tons annually, a figure exceeded only during the war years of 1943 and 1944. Nevertheless, leading producers have begun voluntary allocation to halt a wave of scare buying. The leading U. S. aluminum producer recently revealed that there is no severe shortage of pig and ingot aluminum and that its allocation was prompted by growing evidence that some consumers were stocking up in apparent fear that their source of supply might be shut off or curtailed.

It is estimated that only 10% of current aluminum production will be required for the proposed partial mobilization, mostly for aircraft. Furthermore, the Government has moved to increase domestic and foreign production for defense. More than $6 million of ECA funds have been earmarked for a bauxite plant in Jamaica, which will produce 40,000 tons of alumina per year by the end of 1953.

But more immediate production, a 100,000 ton-a-year increase, has been predicted by the Munitions Board as the result of de-mothballing unused production capacity. This increase will bring aluminum production above the 1944 figure and to less than 100,000 tons per year under the record 1943 figure of 920,179 tons. Several additional plants are to be placed on a standby basis.

Magnesium

Magnesium producers are confident that, for most products, consumer demands for magnesium can be met in the face of increased demands for military uses. While there has been no significant evidence of scare-buying, the nation's largest producer instituted voluntary allocations in mid-September to assure an adequate supply for military requirements.

The principal military uses of magnesium are in aircraft and airborne equipment. To allow for the increased demand that will accompany expansion of our air force, the Government has authorized the reopening of five of the seven magnesium plants which have been kept in reserve since World War II. It is believed that full production can be attained within 90 days in all of these plants. With good foundry and extrusion capacity available, the only bottleneck in magnesium production is believed to be the mill capacity for the rolling of magnesium sheet. A recent Government announcement, however, revealed that a large new continuous coil rolling mill, to be constructed at Madison, Ill., will ease the magnesium sheet situation.

The only serious problem facing the magnesium industry during World War II was a shortage of electric power, but this was overcome by the adoption of the ferro-silicon process for the production of magnesium.

Copper

Stocks of copper in the hands of producers, fabricators and consumers are reported to be at an all-time low today. Fighting in Korea merely added to a heavy industrial demand which has exceeded supply almost constantly since before World War II. Because not enough copper stock is available, a number of copper mills recently reduced their working week from six to five days.

Chief among the reasons for reduced copper supplies have been a temporary slump in imports from Chile, where strikes have cut down production, and the reluctance of importers to take copper out of bond at this time. Meanwhile, industry leaders have unleashed a barrage of criticism at the Senate Finance Committee for tabling a copper import tax suspension bill. Retention of the 2¢-per-pound tariff, they argue, is holding down imports of copper at a time when it is needed most.

Optimum U. S. copper production is considered to be around 900,000 tons annually, although slightly more than a million tons annually were produced during World War II. Estimates of demand for copper during the next 12 months, however, run as high as 2,000,000 tons, meaning that, even with increased production at home, we will have to import 40 to 50% of our copper needs. Chile, Mexico and Canada are, at present, our chief suppliers of copper.

In an effort to conserve copper, many shell casings are now being made with steel instead of brass. But copper continues to be one of the vital war metals. More than 1500 tons of copper, for instance, are required to build a battleship of the Iowa class, a B-29 requires three tons, and landing craft and tanks use one ton each. And, with ever-increasing use of electronics in warfare, copper wiring and contacts are in greater demand.

Producers of civilian goods can expect no alleviation in the tight copper situation in the near future.

Nickel

Despite the fact that the annual production of primary nickel in the U. S. is less than 1000 tons, the possibility of serious shortages of this im-

portant metal, even in the event of all-out war, is remote.

Fortunately, close to 80% of the world's production of nickel comes from our northern neighbor, Canada. And since Canada's fortunes are closely allied to ours in the present crisis, U. S. industry is not likely to be in want of nickel or in need of substitutes. At present, a temporary shortage exists and voluntary allocation has been instituted by nickel producers. But, as in the case of so many other important war materials, scare buying has been largely responsible for the short supply. Production is being expanded in Canada to meet the increased demand, while the U. S. is planning to reopen a Cuban nickel plant.

Use of nickel enters into many ferrous and nonferrous products, most of which have military significance. The steel industry, of course, is the greatest consumer, having taken 60 to 70% of the available output during World War II for alloy steels. Although the aircraft industry has always been a heavy user of nickel alloys, jet plane production has increased its demand even more. Heat resisting nickel alloys are vital for combustion chamber liners, exhaust pipes, rotors, blades, bolts and other highly-stressed jet plane components operating at elevated temperatures.

Radar, loran, and other electronic devices require great amounts of nickel for cathodes, anodes, grids, lead wires and permanent magnets.

Chromium

While America uses about 48% of the world's chromium ore production, it mines only 2% of its normal needs annually. Until recently, however, imports of this vital alloying metal more than made up this deficiency, allowing us to increase our government and industry stockpiles considerably. But after the first quarter of 1949, Russian exports of chromium to the U. S., which had reached a record high of 352,000 tons in 1948, were completely cut off. This move, in retaliation for a U. S. embargo on machinery or other equipment that might be used for war production, deprived us of one of our largest sources of chromium ore.

Fortunately, this counter-embargo by Russia has been partially offset by increased Turkish ore exports, which rose from 52,000 tons in 1947 to 200,000 tons in 1948 and 227,000 in 1949. Other sources of chromium ore are South Africa, averaging 230,000 tons for the last three years, Cuba, the Philippines, and Southern Rhodesia.

Current shortages of chromium in industry are probably being caused by heavy government stockpiling and the widespread scare buying. A glance at the map is enough to indicate why stockpiling has been accelerated. In the event of all-out war, it appears likely that chromium sources in Turkey and, perhaps, the Philippines will be cut off. For the time being, however, we have a comfortable supply, and steel, refractory and chemical producers should have no difficulty in filling most of their chromium requirements. Big users of chromium for plating, such as the automobile industry, will find their supplies cut slightly, but not enough to require the wholesale substitution resorted to in 1941.

Manganese

Manganese is ranked by many authorities as the United States No. 1 strategic material. It is required as a deoxidizer and desulfurizer in the manufacture of steel; approximately 14 lb. are used in every ton of steel produced. A manganese shortage in time of emergency would constitute, therefore, a dangerous bottleneck curtailing the output of steel.

Russia supplied us with 427,000 tons of manganese ore in 1948, ranking her first among our suppliers. Then came the embargo in 1949, cutting off all but 81,000 tons, which were shipped during the first quarter of the year. At present, no manganese is reaching us from Russia, but the deficiency is being made up by increased shipments from the Gold Coast and Transvaal in Africa, and from India and Brazil. Plenty of manganese exists at various places in the U. S., but it is of too low a grade to make refining commercially feasible. Nevertheless, the deposits are being investigated and concentrating methods developed to meet a possible emergency. Also, the 10% manganese content of steel furnace slags offers a possible, but costly, source. Exports from a huge Brazilian development are expected to supply 300,000 tons annually, but not until the middle of 1952, at least.

The tight situation in manganese today can be directly linked to record steel production and accelerated government stockpiling, but steel producers, so far, have not encountered much difficulty in meeting their requirements.

Zinc

Enough zinc is now being processed in the U. S. to provide almost normal consumer consumption if the Korean war remains localized and mobilization plans are not revised according to spokesmen for the zinc industry. U. S. produces a large percentage of its needs, with Canada and Mexico supplying our largest imports; so there is little danger of short supply in the event of large-scale warfare.

Zinc finds its chief war uses in brass, dry cells and die castings, although galvanizing, its greatest peacetime consumer, has many indirect uses in a war effort. The amount of brass produced, however, usually depends on the copper available, since copper is usually in shorter supply than zinc. Galvanizing, on the other hand, decreased during World War II because of shortages of iron.

As was the case with other materials, the critical shortage of zinc which arose in July was due primarily to hoarding and the doubling of government stockpiling within the last year. In an all-out war effort, lack of manpower could be the greatest peril to our zinc output. During World War II, many miners who had been drafted were discharged and sent back to zinc and lead mines when production began to lag.

Lead

Although the lead situation is temporarily tight, spokesmen for lead producers anticipate little difficulty in supplying all forseeable demands, including requirements for an all-out war. Contributing to the present short supply of lead are scare buying, low inventories (caused by recent high prices), and a genuine expansion of consumer demand.

The tremendous increase in automobile production and the great number of cars on American highways, using record-breaking quantities of storage batteries and tetraethyl lead (in gasoline), are, more than any other factors, responsible for the great demand for lead today. In addition, the building boom and the resulting increase in the use of lead-base paints have added to the load.

While lead is not the war metal that copper, zinc and steel are, it makes several direct and many indirect contributions to the military. The largest uses of lead in wartime

are in small arms ammunition up to 50 cal., storage batteries and tetraethyl gasoline. (With the ever-increasing proportion of military aircraft being jet-powered, the amount of high-test gasoline needing tetraethyl lead is decreasing because jets use comparatively crude petroleum products.) One very common misconception debunked by lead spokesmen is that great amounts of lead will be required for shielding in our atomic projects. While lead is important in atomic energy work, they assert, only one-tenth of 1% of the nation's output is now being used for that purpose.

Hard pressed by a record peace-time economy, the nation's steel industry now must gird for the additional burden of war production. Expansion plans call for a capacity of 105,700,000 tons per year by the end of 1952. (Courtesy Carnegie-Illinois Steel Corp.)

Lead was in plentiful supply during World War II, the only shortage occurring when too many lead miners were inducted into the armed forces. In the event of another world-wide conflict, the nation is assured of a large supply of lead from within its borders and additional supplies from Canada, Mexico, South America and Australia.

Other Strategic Metals

Tin—Although our largest supply of tin comes from Bolivia, important tonnages are also imported from Indonesia and Thailand (Siam), both of which would probably be cut off in the event of large-scale war in Asia. Tin supplies are ample now, but the Government is accelerating its stockpiling. Government allocation controls, ended only last January, may be instituted again.

Tungsten—Domestic production of tungsten is inadequate for U. S. requirements in tungsten steels and tungsten alloy tools. China and Korea supply us with approximately 60% of our imports and, because of the uncertainty of future shipments from that area, stockpiling has been accelerated. But there should be no difficulty in obtaining supplies in the near future.

Columbium—Used to improve impact strength, heat resistance and weldability of steel, and to stabilize stainless steels, this alloying element is now critically short because of increased demand for high temperature metals and stainless steels. Major supplies of columbium come from Nigeria, Belgium Congo, Brazil and Bolivia, but resources in Nigeria, our best source, are becoming depleted. A bright spot in the picture is the recent introduction of more available titanium and titanium-columbium combinations as substitutes.

Plastics

With the sudden expansion of the synthetic rubber capacity and the prospects for greatly increased consumption of aviation gasoline, many plastic products based on benzene and styrene (which uses benzene in its production) are expected to feel the squeeze. The effects of the rearmament program on these and other plastics is reviewed in the following breakdown:

Polystyrene—The diversion of benzene and styrene to defense production will undoubtedly hurt the production of polystyrene. But, with polystyrene coming into widespread use, it should have many military applications, also. Undoubtedly, therefore, materials will be diverted for its production for military purposes, but civilian producers will have to expect a cut.

Phenolics and Alkyds—These plastics also need benzene, but have many essential war and civilian uses. Sufficient supplies will probably be provided.

Acrylics—At the present time, there are adequate supplies of acrylic molding materials and fabricating stock. It appears that adequate raw material and production facilities are available to fill forseeable military needs and reasonable commercial requirements.

Cellulosics—While the latest government figures on cellulose plastics show a considerable improvement from 1949, indications point to further demand increases. There is slack to be taken up, however, before shortages are likely. Although there appears to be adequate raw material supplies, further expansion will be limited by conversion facilities.

Nylon—Nylon is one of the heavy users of benzene, but also is an essential military material. Sufficient benzene supplies will be available for nylon's use in the rearmament program, but civilian nylon should be more difficult to procure.

Polyethylene—Already in short supply, polyethylene is used for many military applications. While plant capacity is being increased to allow greater production, military demands will probably preclude further expansion of nonessential uses.

Melamines—The supply of these plastics and chemicals required for its production are ample for all forseeable civilian and military needs.

Ureas—Supplies of ureas are sufficient at present, but their production is dependent on nitrogen, which finds both military and agricultural uses.

Vinyls—To some extent, the vinyls are influenced by the rubber supply situation, since they are often used as substitutes for rubber. There should be adequate supplies of vinyl for both civilian and military purposes.

Rubber

Facilities for raising production of synthetic rubber to 755,000 tons per year are being reopened by the Government as a result of war in the Far East. Additional facilities, which could quickly raise production to nearly 1,000,000 tons per year, are available. These figures are in contrast to the 4500 tons of synthetic rubber capacity available to the nation in 1940. Meanwhile, the Government, under prodding from the Senate Armed Services Preparedness Committee, has begun to increase the stockpiling of natural rubber. To increase natural rubber supplies further, the rubber industry is expected to begin using a greater percentage of synthetic rubber in final products. One likely effect on civilian production, if rubber supplies become short, will be the disappearance of the spare tire from new automobiles.

Chromium Is Plated Directly on Aluminum by New Process

by T. C. DU MOND, Editor, Materials & Methods

Wear resistance and anti-frictional qualities of many aluminum parts can be improved by chromium plating.

● A NEW PROCESS of plating chromium directly onto aluminum gives promise of extending still further the usefulness of that versatile material. The lightness of the base metal, plus the hardness, wear resistance, corrosion resistance and anti-frictional qualities of chromium, make a strong and mechanically attractive combination for many uses.

The direct plating process was developed and is being patented by Cro-Plate, Inc. The process evolved after considerable searching for a more economical method of coating aluminum to provide wear resisting surfaces. The method has now been proved by a number of applications over the past year or more. Already chromium-plated aluminum is being used in gearing, for plug gages, electrical parts, ball bearings, ring seals, pulleys, and many other parts. As yet, decorative aspects of the method have not been investigated. Wrought, sand cast and die cast aluminum alloys can be plated with equal ease. In addition to seeking patents on the process, Cro-Plate manufactures the equipment necessary to its proper execution.

Aluminum, in common with some other corrosion resistant materials, is protected from the atmosphere by an oxide coating that forms immediately upon contact between the metal surface and the atmosphere. It is this oxide coating which makes the plating of aluminum difficult. In fact, many coatings applied to aluminum are not bonded directly to the base metal, but are held on by the oxide coating or some other separating layer.

Two rather widely used plating methods in use today have the additional disadvantage of requiring at least one additional step between cleaning and plating. In addition, as many as three plating baths are used to attain the same results now obtained with one plating step. Most frequently used is a process which starts with a zincate bath. The zinc deposited by the bath serves as a base for subsequent plating by copper, nickel, and then the chromium. A second popular method requires that the aluminum be anodized. Plating is then done on the anodized surface.

In searching for a way to plate directly on aluminum without any of the usual intermediate steps, Cro-Plate engineers looked for a method of coating which would protect the aluminum surface between the time it was mechanically cleaned of both dirt and oxides and its immersion in the plating bath. In addition to preventing any contact between the air and the aluminum surface it covered, the coating had to be inert so that it would not contaminate the plating bath. The answer seemed to be in the abrasive material used in wet blasting metal surfaces for cleaning and finishing. Investigation showed this premise to be true.

The Process

Here, briefly, is how the process works. Aluminum to be plated is wet blasted by an abrasive suspended in water. After being blasted, the aluminum surface retains a coating of the suspension thick enough to prevent any action by air on the mechanically cleaned aluminum for a period long enough to permit the aluminum to be immersed in the plating bath. Once in the acid bath, the coating washes away from the aluminum surface and settles to the bottom of the tank. To insure maximum efficiency, the blasting machine is placed next to or in close proximity to the plating tank.

As a comparison which will show how time and money can be saved by the new process, we note that the

1. *Aluminum parts to be plated are first given a thorough wet blasting by a fine abrasive suspended in water.*

most commonly used method now employed involves:

1. Chemical cleaning
2. Zincate bath
3. Copper plating
4. Nickel plating
5. Chromium plating

By the process developed, only two steps are required, namely:

1. Wet blasting
2. Chromium plating

Examination of plating done by the new process shows that there is a very definite integral bond between the plated material and the aluminum base. There is no oxide coating or other separating layer between base and plated coat.

The abrasive material used is quartz crystal (silicon dioxide). This material is hard and, of importance to this process, is chemically inert. When the quartz crystal is washed off the aluminum in the plating bath, it settles harmlessly to the bottom of the tank.

Action of the abrasive is important in the plating process. First, the hard crystals knock the oxide from the aluminum surface to permit plating. The crystals are cube-shaped with rounded corners. When the crystals strike against the aluminum surface, they create a myriad of microscopic hills and valleys as they clean and smooth the surface. The result of the action is to actually increase the surface area of the part by about ten times. The increased surface area adds to the bonding action between the plated coating and the base metal.

Chromium can be deposited on aluminum at the rate of 0.007 to 0.008 in. per hr. by means of a special high-speed plating solution used with the process. The coatings deposited will have a hardness of between 75 and 82 Rockwell C.

The costs of plating chromium on aluminum by the direct process are equal to or less than standard chromium plating of steel by conventional methods.

Present and Potential Uses

There are three important mechanical advantages to plating aluminum with chromium. First, the aluminum is made more wear resistant. Second, the impact value of plated aluminum approaches that of unplated mild steel. Finally, surface friction is reduced by plating aluminum with chromium. This is, of course, important where parts are to slide against each other.

Aircraft applications are expected to use many types of chromium-plated parts. The combination of light weight and wear resistance makes plated aluminum useful on all kinds of transportation equipment and for many products which must be portable.

Already the wear resistant property of chromium-plated aluminum has resulted in its use on aircraft planetary gears. A second aircraft use is in the manufacture of ring seals. Here the application requires a surface flatness of 25 microinches, which can be attained with the standard equipment used for wet blasting.

A variable pitch pulley, sand cast from an aluminum alloy, is now chromium plated on all wear surfaces, inside and out. The original cast pulleys wore unevenly on the bore. Plating corrected this. However, the belt then started cutting through the sheeve. Again, plating on the wear surface permitted aluminum to serve in the application.

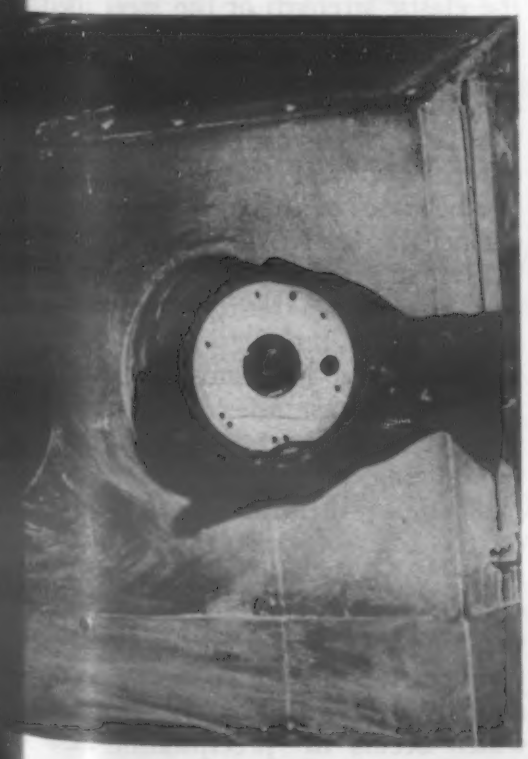
In another case, aluminum balls used in a machine gun mount were work hardening out of shape through a peening action as they hit against each other. Chromium plating stopped the trouble. The plated balls run in magnesium races.

Plating Other Materials

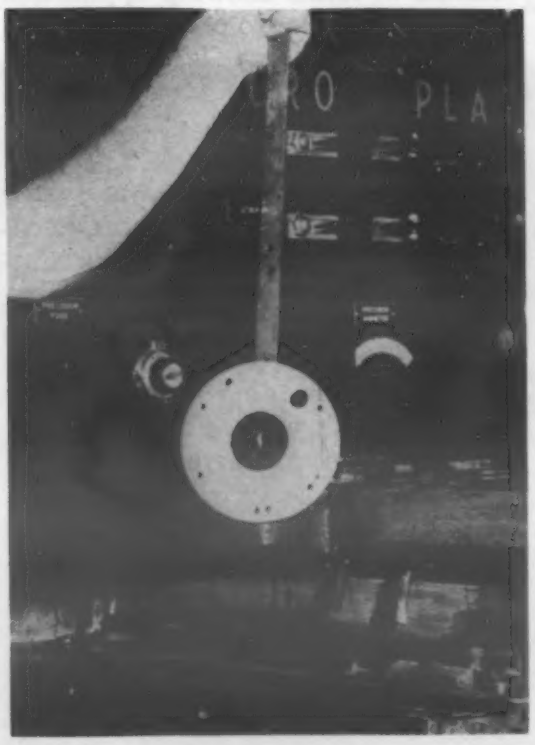
Maximum use of the direct plating process is expected to be in the chromium plating of aluminum, but its usefulness does not end there by any means.

For example, the identical procedure can be used to plate any of the commonly used plating metals to any base metal with the exception of magnesium. Plating on steel can be done without intermediate coatings, such as copper. Thus, the method is faster and less expensive. Likewise, plating of zinc die castings is made easier and more certain.

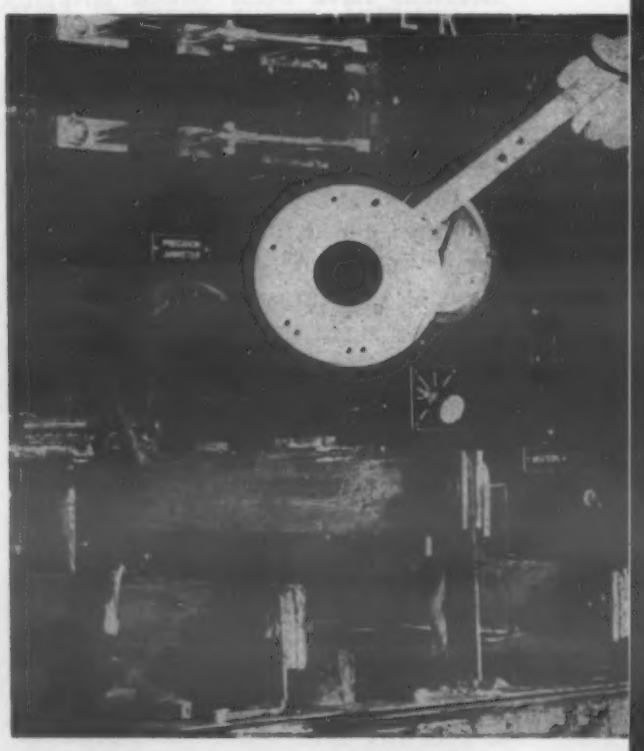
***2.** As a result of the blasting, the aluminum part is covered with a fine coating of abrasive which effectively shields the aluminum from action of the air.*



***3.** When the protected part is placed in the acid plating bath, the inert coating drops harmlessly to the bottom of the tank.*



***4.** The matte surface of the aluminum results in a dull, rather than bright chromium plate. A high-speed bath permits a thick chromium plate in minimum time.*



Research Shows How Pickling Causes Brittleness in Stainless Steels

by CARL A. ZAPFFE, Consulting Metallurgist

Fundamental studies on the behavior of gases in steel have resulted in a better understanding of the difficulties encountered in pickling and have suggested ways of avoiding failures.

• IN THE CLEANING OF iron and steel, processes are commonly used which expose the metal to absorption of hydrogen gas. Reference is specifically made to acid pickling, also cathodic pickling. It has long been known that steel can be importantly damaged by hydrogen, and that injurious quantities of this gas can be absorbed during acid pickling. However, (1) the manner in which the gas causes the damage, (2) the exact conditions under which damage occurs, and (3) the detailed nature of the recovery of steels embrittled by hydrogen—these matters have remained largely unexplained.

For the past five years there has been conducted in the author's laboratory, under sponsorship of the Office of Naval Research, a fundamental study of the bahavior of gases in metals, particularly hydrogen in steel. Numerous technical reports and publications have been issued covering the results of this research. However, these have been for the most part written from the standpoint of metallurgical theory, and they have appeared in journals not frequently read by the plant metallurgist or engineer.

Because much of the research directly concerns some important industrial problems, it has seemed advisable to reassemble certain of the contributions and to describe them specifically from the standpoint of their possible application to metallurgical problems in industrial processes.

In the course of the present research, many points became clarified. Among the discoveries that were made, one of the most surprising concerned the great sensitivity of the hardenable grades of stainless steel to pickling brittleness, and specifically the fact that commercial inhibitors added to the pickling solution customarily *increase the embrittlement beyond that caused by the raw acid.*

This is clearly a matter of prime concern, for the hardenable stainless steels frequently present difficulties from breakage during wire drawing, and cracking and splitting during cold-heading operations and similar processes involving cold work. It is a contribution of this research to isolate important causes of many such difficulties, to provide an understanding of their fundamental nature, and to recommend procedures for their minimization or avoidance. The steels in question actually have a considerably wider range of workability than commonly believed because of unsuspected or uncontrolled interference from hydrogen; and a principal purpose of the present writing is, therefore, to describe the damaging factors in terms allowing application of the knowledge to plant practice.

A Microscopic View of the Embrittlement Process

While it is not intended to discuss theoretical aspects of embrittlement beyond their immediate usefulness, it is important for anyone involving himself with a problem of brittleness in the plant to have at least a simplified understanding of the manner in which hydrogen embrittles steel. This can now be given so descriptively that its grasp is relatively easy.

In Fig. 1, a sketch shows a metal —which can be understood to represent any type of steel—containing some typical scale on its surface which is being removed by pickling in an acid solution. Hydrogen ions (H^+), which are the chemically active units of hydrogen in the pickling solution, lose their positive charge at an area of exposed metal on the left, forming hydrogen atoms (H) which, because of their small size and their chemical attraction to iron, are enabled to diffuse direcly into the atomic structure of the iron. These H atoms are represented in the sketch as black dots.

Once within the iron, however, these atoms immediately recombine wherever the atomic structure is slightly loosened; and they form in this manner tiny micro-pockets of entrapped molecular hydrogen gas (H_2). The pockets are indicated as "planar occlusions" in Fig. 1.

As will soon become clear, this is important to know, for hydrogen does *not* do its damage to steel by forming a brittle compound, as was long believed, but instead by developing pressures of microscopically entrapped gas which actually exceed the elastic strength of the steel itself.

Furthermore, these entrapments are now known to occur along the same crystallographic planes within the iron which are operative in plastic deformation and fracture[1]. The entire behavior of this gas: first, in rendering the steel brittle and, second, in later stages of its removal from the steel to allow a return of ductility, involves this unique process of infusion as hydrogen atoms and internal precipitation as molecular hydrogen gas. All techniques for avoiding, or minimizing, or removing embrittlement must, therefore, be conceived on the basis of this general picture, rather than the earlier chemical one of hydrides and atomic diffusion, which is at best a minor aspect. The precipitation of the hydrogen, incidentally, is little different from that which occurs in "precipitation-hard-

ening" alloys, such as Duralumin and beryllium copper, except that here the precipitant is a gas.

Proceeding now to Fig. 2, the technique of "fractography" (direct viewing of the natural fracture face at high magnification) is employed to show the microscopic characteristics which corroborate and illustrate the description just given. A specimen of mild steel, heated at 1830 F for 2 hr. and furnace cooled, was subsequently slightly embrittled by hydrogen in a pickling bath and was then fractured at the temperature of liquid nitrogen (−320 F). The steel broke without important prior plastic deformation; and Fig. 2 shows, at a magnification of 475 times, the path of the fracture through a single grain, part of whose boundary is visible as a dark profile at the left. A number of rectangular block-like areas appear to one side of this grain, and these can be understood to express hydrogen embrittlement. The large blocks are visually suggestive of the diagrammatic blocks shown in Fig. 1; and this is a useful approximation, except that they are actually vast composites of the tiny sketched blocklets.

In Fig. 3, a specimen of ingot iron is shown fractographically after an extended pickling treatment, such that it readily fractured in a brittle manner at room temperature. The specimen had been annealed at 2282 F for 2 hr. and furnace-cooled to grow large grains, and the entire field in the illustration belongs to a single grain. An elaborate and fine-scale architecture is now visible, the crystal being highly subdivided by internal precipitation of the embrittling gas; and the tiniest visible units in the pattern are believed to be closely related to the units in the sketch in Fig. 1.

According to a new theory for the structure of solids such as metals—which will be mentioned here because it expressly explains the embrittlement phenomenon—each grain comprises from the time of solidification a vast mass of extremely small clusters of atoms, the clusters being called "micelles." The individual micelle is the individual blocklet in Fig. 1; and the pockets of occluded gas are accordingly presumed to form in between the micelles which form the grain. Since these, in turn, are presumably the units which slip during plastic working, the precipitation of the gas understandably interferes with slip, and hence registers mechanically as a loss in ductility.

Returning again to Fig. 1, the path

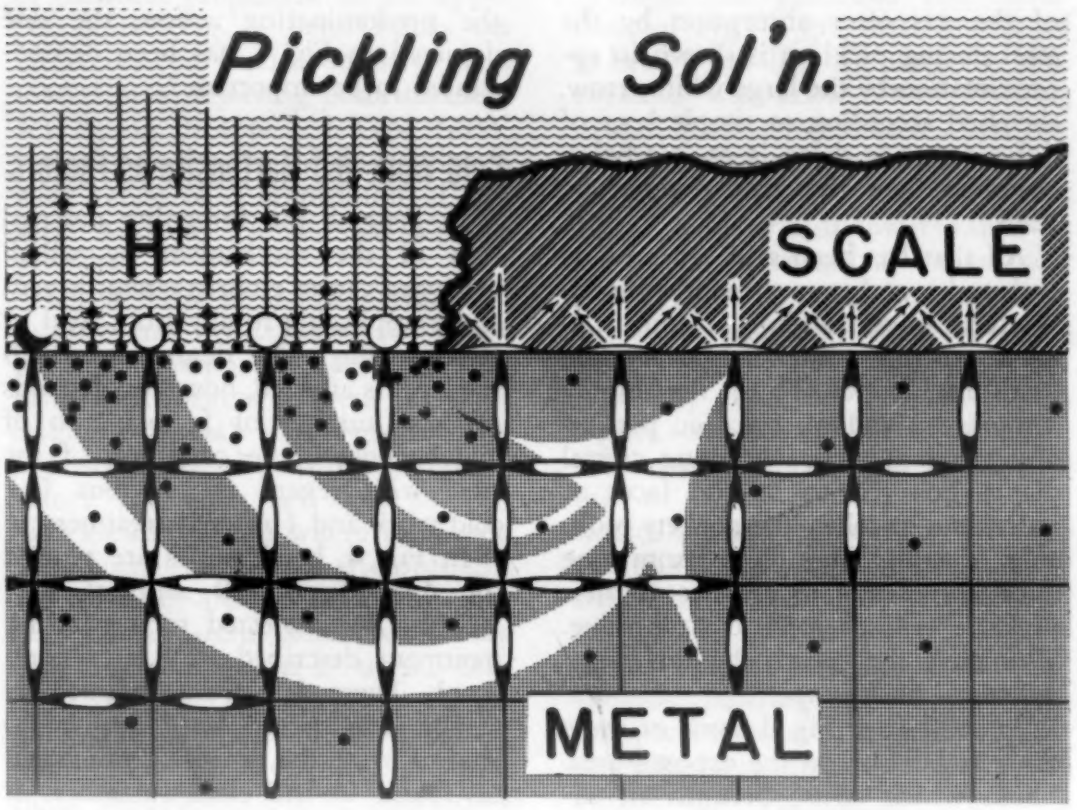


Fig. 1—Diagrammatic sketch of the action of hydrogen in an acid pickling process.

Left: Fig. 2—Microscopic view of the beginning of "pickling brittleness."

Below: Fig. 3—Fractograph of ingot iron subjected to severe pickling brittleness.

of the gas after absorption by the steel during pickling is shown in approximation by the large white arrow, sketched according to simple laws of diffusion since there is no gas being absorbed over the area covered by scale.

All that has been said can now be gathered together to provide a broadly useful understanding of embrittlement, also a new concept for the descaling action. Thus, the highly compressed and microscopic pockets of hydrogen gas travel along crystal planes believed to be the faces of individual micelles, the pockets probably blasting their way from one micellar position to another as their pressure exceeds some critical value. Ultimately they reach the surface of the metal and escape.

At the left of Fig. 1 some of these show as bubbles on the exposed area. Those which effuse beneath an adjoining layer of scale explode the scale away, much like this gas is known to do in the "fish-scaling" of enameled ware[2]. Previously it has been thought that the scale was removed by acid which penetrated tiny openings in the scale and developed explosive pressures of hydrogen upon contacting the metal. Whichever is the predominating action, the one depicted in Fig. 1 has been demonstrated to be important[3].

Cold Work and Martensite as Factors

In general, the foregoing description of the mechanism by which hydrogen causes embrittlement is generally applicable to any iron, steel or ferrous alloy. The degree to which the steel is affected, however, depends upon a number of factors, two of which concern the condition of the steel with regard to previous (a) cold work and (b) heat treatment.

In Fig. 4, bend values are plotted for AISI Type 410 stainless steel (12% Cr) subjected to a pickling treatment described in a later paragraph. These data were obtained by means of a special test[4] applied to 0.06-in. wire, the details of which can be found in the cited reference. It is only important here to notice that *bendability* is being used as a measure of hydrogen embrittlement, and that the bend angles, ranging from zero to a "full bend" of 180 deg., are shown vertically on the left of each graph.

In the Figure, Type 410 is shown to sustain a bend of 180 deg. in all conditions previous to pickling, and to retain that full bendability throughout a pickling period of 2 hr. when (a) annealed or (b) annealed and cold drawn. However, when hardened, Type 410 shows a loss of bendability within the first few minutes of pickling, dropping to very low values near 50 deg. When, in addition, the hardened steel is cold drawn and then pickled, the full bendability is lost within a minute or two, and the values drop to as low as 10 and 12 deg. This is an extremely brittle condition—comparable to Type 440-C, one of the most difficult to work of all the stainless steels.

Cathodic pickling was used for obtaining the data in Fig. 4. The electrolyte was 10% NaOH, temperature 122 F and the current density 1 amp. per in.[6], the steel being made the cathode. This type of pickling was chosen for disclosing the effects of these factors within the steel itself, because the bombardment of the steel by hydrogen can be made constant for all tests by controlling the current density. In acid pickling, the true relationships with hydrogen can be obscured by the fact that the steel reacts differently with the acid when in the different conditions, and hence creates differing hydrogenizing effects

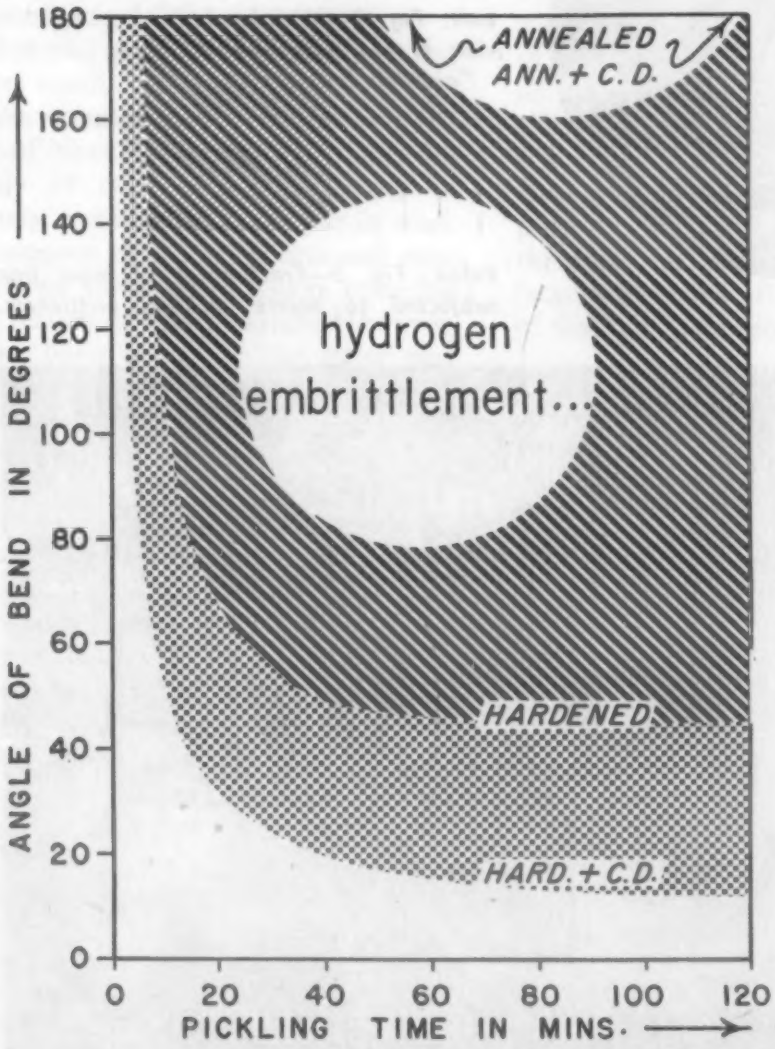
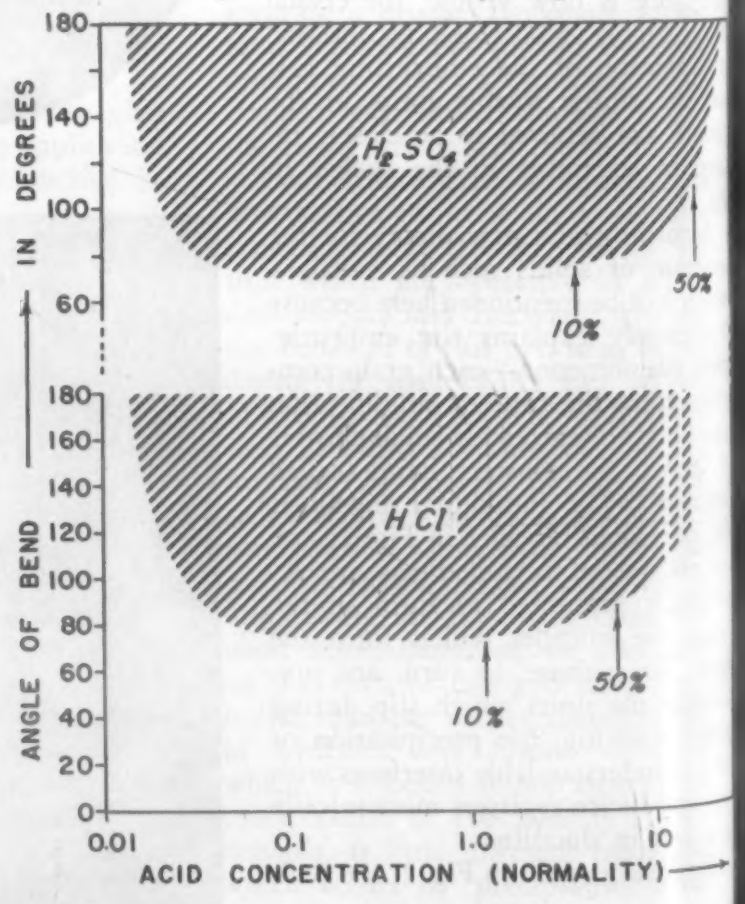


Fig. 4—Pickling brittleness related to the condition of the steel.

Fig. 5—A study of acid type and concentration as factors in pickling brittleness.



To solve the general problem, it is important first to isolate cold work and heat treatment as factors. As for the actual embrittlement of these steels in acid pickling, this is a special problem whose separate exploration constitutes a second step.

From much data similar to that in Fig. 4, it can be concluded that: (1) steel is much more susceptible to embrittlement when in the hardened condition, and (2) cold working further increases the susceptibility of steel in any condition. While the data in Fig. 4 show no difference between annealed steel and the same steel subsequently cold drawn, other tests confirm the stated effect of cold working. A full-bend does not designate complete immunity, but only comparative immunity, and is simply the limit of sensitivity of the test.

Other Factors

Frequently there is heard an opinion that greater or less embrittlement follows from pickling with one or another type of acid. This matter has now been explored [5], and two sets of data in Fig. 5 summarize the results for the two most important commercial pickling baths: sulfuric and hydrochloric acids.

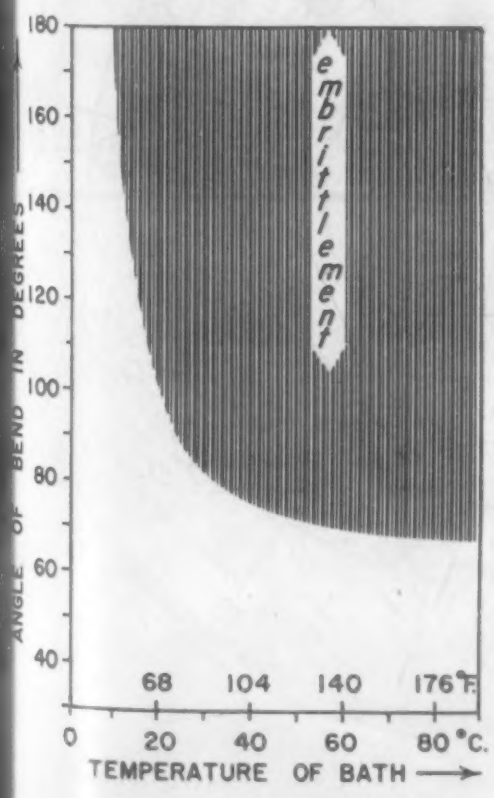
Once again a method of study is adopted which provides a disclosure of fundamental effects—this time by plotting the bend values against *normality* as an expression of acid concentration, because normality is the chemical expression directly relating to chemical properties. In the upper portion of Fig. 5, bend values are shown as the underboundary of a shaded area depicting embrittlement developing in annealed Type 440-C stainless steel wire pickled over a wide range of concentration of sulfuric acid at 150 F, for 15-min. periods.

On a basis of equal normalities, sulfuric and hydrochloric acid baths disclose no important difference. Embrittlement begins at about the same dilution in each case, proceeds to approximately the same minimum values, and then rises again at very high concentrations where ionization is importantly reduced. Accordingly, the two acids are fundamentally similar, any apparent differences being due to a comparison of unlike concentrations, or to passivating effects. Sulfuric acid results in the return of a full bend at very high concentrations. Hydrochloric acid indicates a similar action, but concentrations in the very high range are not readily explored.

To facilitate interpretation of the data in terms of commonly used pickling concentrations, there is indicated on the graph the positions of 10 and 50% solutions, based upon volume percent of the common concentrated acids.

In Reference 5, a special study goes on to show that most of the common acids cause embrittlement which is almost identical with that given here for sulfuric and hydrochloric acids, the minimum and maximum concentrations differing somewhat, depending upon ionization of the acid. There was similarly demonstrated in the case of cathodic pickling that the choice of electrolyte makes little if any difference[4]. With other factors held constant, embrittlement is equally severe whether an alkaline or acid solution is used.

Fig. 6—Temperature of the pickling bath as related to embrittling power.



Temperature of the Bath

Although the temperature of the pickling solution is usually governed by other reasons, it is interesting to know how pickling brittleness varies with temperature. The answer to this stands in Fig. 6, where bend data are plotted for 15-min. pickling periods in 1-N sulfuric acid over the entire range of commercially used temperatures. The specimen is Type 440-C stainless steel, which is particularly sensitive to hydrogen embrittlement and is, therefore, used in many of the tests to serve as a detector of embrittlement.

Under the particular test conditions of Fig. 6, the wires continued to bend a full 180 deg. until the temperature was raised from freezing toward room temperature. Then embrittlement sharply initiated, proceeding to low values in the range near 122 F, and to still lower values in the higher commercial range near 176 F. Because mild heating treatments are known to expel hydrogen from steel, the mistaken idea is occasionally expressed that pickling at higher temperatures leads to less embrittlement. The present data prove this to be in error, embrittlement worsening continuously as the temperature increases. Nor can this increase be blamed upon greater acid attack, for similar tests conducted under standardized conditions of cathodic pickling proved embrittlement to be worse at higher temperatures[4-6]. Heat favors the gas going either way—out or in—depending upon which side has the gas during the heating.

A Comparison of Steels

In References 5 and 6, a large amount of information has been presented regarding the comparison of Class I (hardenable) stainless steels and carbon steels on the basis of sensitivity to hydrogen embrittlement. In Figs. 7 and 8, some of the data are summarized. Fig. 7 shows bend values referring to a 10% sulfuric acid solution, and Fig. 8 to a 10% hydrochloric acid.

While there is a reversal of respective positions for SAE 1020 and annealed Type 440-C, also an indication of slightly greater embrittlement for stainless steel in this particular concentration of hydrochloric acid, the two plots are essentially similar and are in keeping with the remarks made regarding the previous Fig. 5.

In Figs. 7 and 8, Type 410 now shows no embrittlement, even when hardened and cold drawn. Compare these results with the data in Fig. 4 obtained from cathodic pickling. The difference is ascribable to the fact mentioned earlier that stainless steel resists chemical attack in general, but different solutions to varying degree. The production of hydrogen is dependent upon chemical attack in acid pickling, but upon current density in cathodic pickling.

On the other hand, it is interesting to find SAE 1090 steel relatively immune to embrittlement in acid pickling. This steel has approximately the same carbon content as Type 440-C,

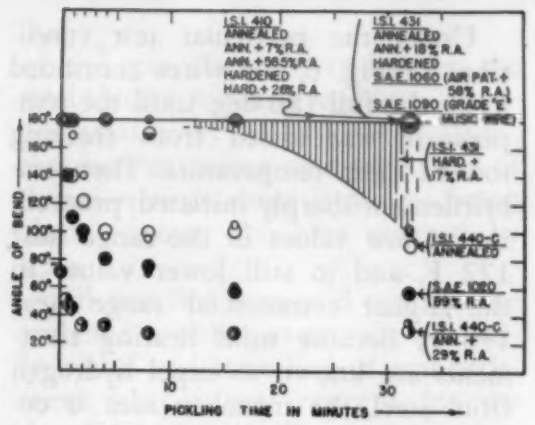


Fig. 7—Comparison of steels pickled in 3.7-normal (10%) sulfuric acid for 15-min. periods at 65 C (150 F).

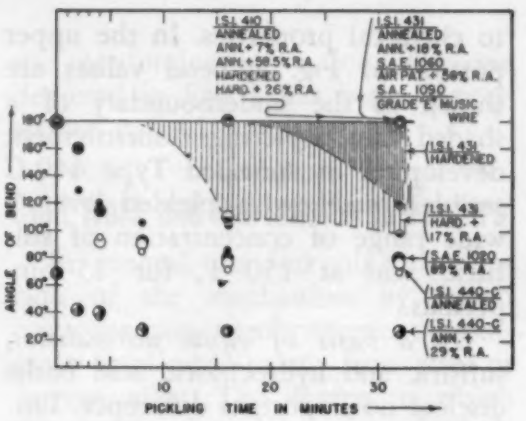

I.S.I. 410 ANNEALED
ANN. + 7% R.A.
ANN. + 56.5% R.A.
HARDENED
HARD. + 26% R.A.
I.S.I. 431 ANNEALED
ANN. + 18% R.A.
S.A.E. 1060 AIR PAT. + 58% R.A.
S.A.E. 1090 GRADE "E" MUSIC WIRE
I.S.I. 431 HARDENED
I.S.I. 431 HARD. + 17% R.A.
S.A.E. 1020 89% R.A.
I.S.I. 440-C ANNEALED
I.S.I. 440-C ANN. + 29% R.A.
ANGLE OF BEND
PICKLING TIME IN MINUTES

Fig. 8—Comparison of the same steels of Fig. 7, now in 1-normal HCl (approximately 10%).

but lacks the chromium. This effect of chromium is frequently demonstrated, but is not understood. Type 431, the grade containing 16 chromium and 2% nickel, is also shown on these plots, and it reveals some susceptibility. This grade is known to be sensitive to hydrogen. For example, coils cannot be processed in the hydrogen-containing cracked ammonia atmospheres without a problem of breaking[7].

Promoter Elements

One of the subtle phenomena involved in pickling brittleness concerns the so-called "promoter elements." These are particularly sulfur, selenium and arsenic, but also phosphorus, telurium and antimony. A specially designed periodic table of the elements, in Fig. 9, shows these "promoters," and they are seen to be closely placed neighbors along radii V and VI in the upper semicircle.

Further discussion of this chart can be found in Reference 8. Here it will only be pointed out that there is a certain class of impurities, common in many steels and in closely related positions on a periodic chart, which are distinguished by the fact that small traces in pickling solutions may increase hydrogen absorption a great many times over that caused by pickling in pure acid. It is especially significant that sulfur, selenium and phosphorus are included among these, for they are frequently added to steels in important proportions to produce free-machining qualities. Many plant problems of brittleness, blistering, and other difficulties traceable to hydrogen are probably the result of the pickling liquor progressively leaching these "promoter elements" out of the steel and storing them in the solution where they can then exert their effect upon subsequent batches of steel. This can account for the occasional blaming of such difficulties on "old pickling liquors."

If a problem is encountered which might be traceable to hydrogen, it is excellent advice to suspect such a changed condition of the pickling solution; and special care should be given the scheduling and pickling of the free-machining grades because of this contaminating influence.

Practical applications of the theories explained in this article will be discussed in a second article in a forthcoming issue of Materials & Methods.

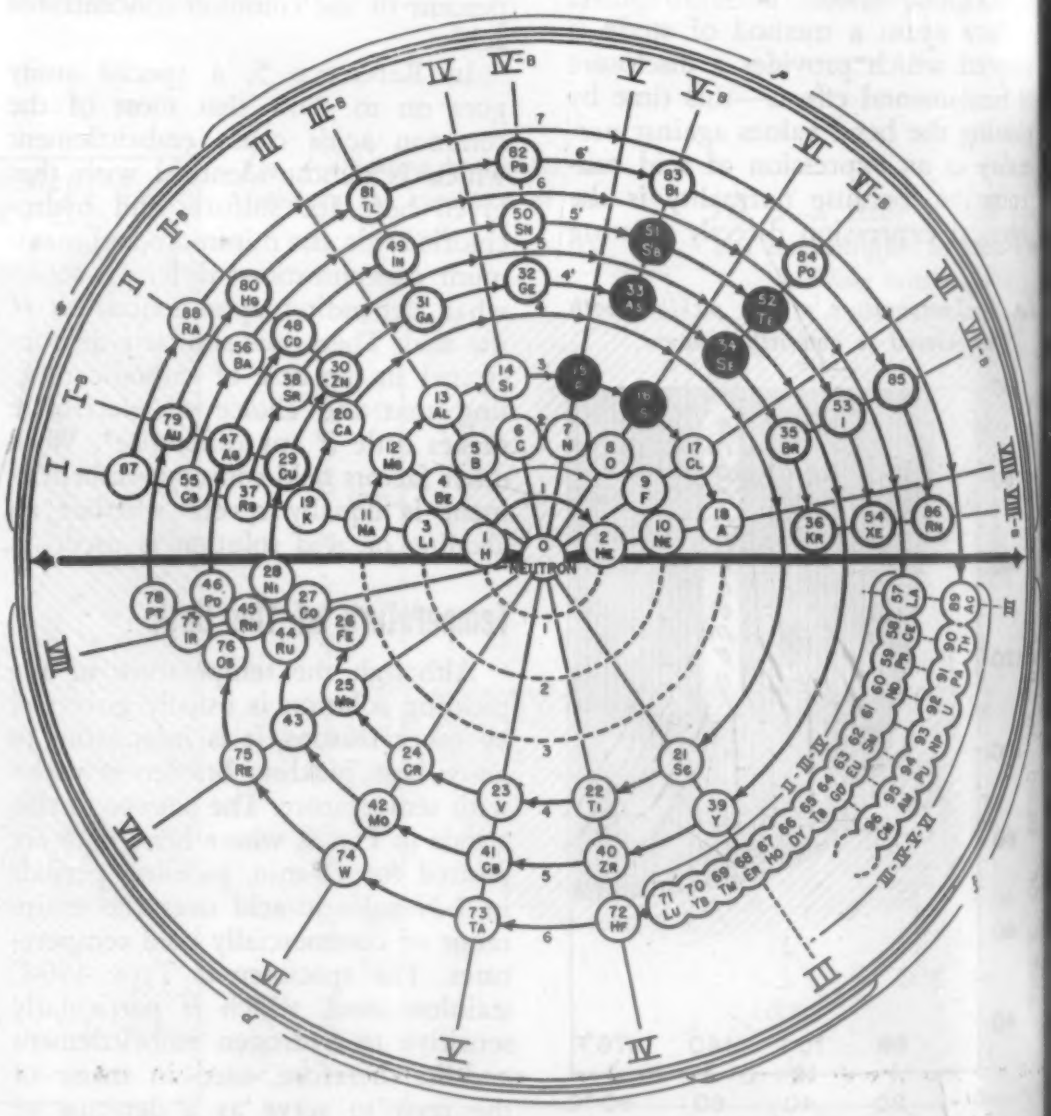


Fig. 9—Special periodic chart of the elements, showing the "promoter elements."

References

The following publications cover most of the work on pickling brittleness discussed here:

1 "Neumann Bands and the Planar-Pressure Theory of Hydrogen Embrittlement", C. A. Zapffe. *J. Iron & Steel Inst.*, Vol. 154, 1946, No. 2, 123p-30p; disc., 130p-1.

2 "Hydrogen in Steel and Cast Iron and Defects in Applied Coatings", C. A. Zapffe & C. E. Sims. METALS AND ALLOYS, Vol. 13, 1941, pp. 444-7, 584-9, 737-42; Vol. 14, pp. 56-60.

3 "Electrolytic Descaling", C. A. Zapffe. *Metal Progress*, Vol. 53, 1948, No. 6, pp. 833-6.

4 "A Test for Hydrogen Embrittlement and Its Application to 17 Chromium, 1% Carbon Stainless Steel Wire", C. A. Zapffe & M. E. Haslem. *Trans. Am. Inst. Mining & Met. Engrs.*, Iron & Steel Div., Vol. 167, 1946, pp. 281-308; disc., pp. 308-12.

5 "Acid Composition, Concentration, Temperature and Pickling Time as Factors in the Hydrogen Embrittlement of Mild Steel and Stainless Steel Wire", C. A. Zapffe & M. E. Haslem. *Trans. Am. Soc. Metals*, Vol. 39, 1947, pp. 213-37; disc., pp. 237-40.

6 "Effect of Composition, Heat Treatment and Cold Work on the Hydrogen Embrittlement of Stainless Steel Wire During Cathodic Pickling", C. A. Zapffe & O. George Specht. *Trans. Am. Soc. Metals*, Vol. 39, 1947, pp. 193-211; disc., p. 212.

7 "Stainless Steels", C. A. Zapffe. *Am. Soc. Metals*, 1949, 368 pp.

8 "A Periodic Chart for Metallurgists," C. A. Zapffe. *Trans. Am. Soc. Metals*, Vol. 38, 1947, pp. 239-65; disc. 265-70.

Zirconium Offers Interesting Properties and Possibilities

Zirconium with its high strength and excellent corrosion resistance is finding many new uses in addition to those in electronics where it is now used extensively.

• IN THE CONSTANT SEARCH for better engineering materials, attention has recently been focused on ductile zirconium. The ores from which zirconium are derived are relatively ample and well located strategically. Although the properties of pure zirconium are interesting and suggest many possible uses, thus far extensive use of the metal has been confined largely to the electronic field.

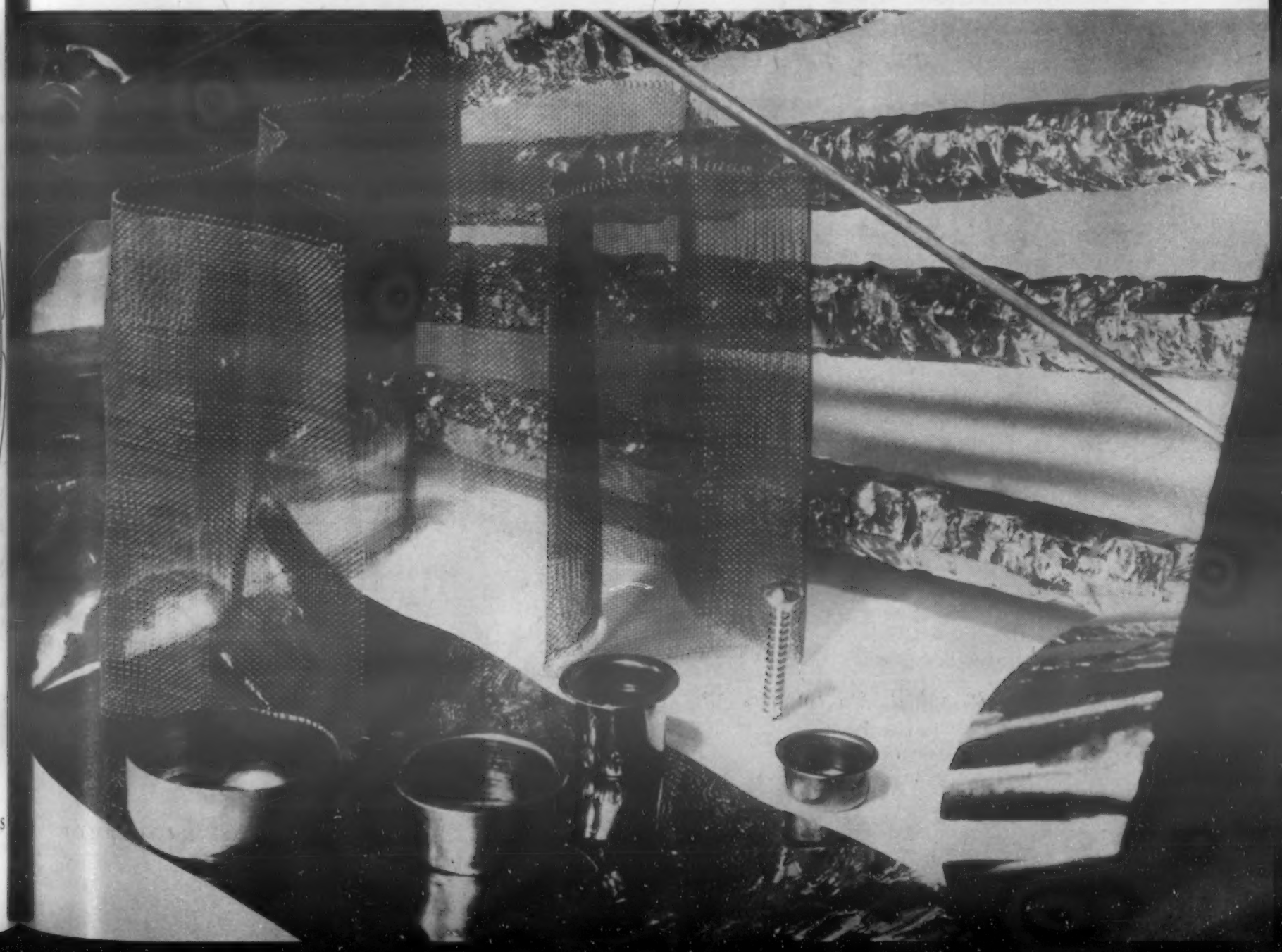
Briefly, zirconium offers high strength and excellent corrosion resistance as its most promising characteristics. Due to an affinity for oxygen and nitrogen and other gases, zirconium must be reduced in a vacuum. Much of the zirconium produced today in this country is made by the iodide process, which results in the production of crystal bars of varying sizes. The crystal bars are then rolled directly into sheet and bar stock.

Because of the difficulty of producing ductile zirconium, its first commercial price was exceedingly high. Increased production and refinements in the reduction process have brought the price down considerably during the last five years. Five years ago ductile zirconium sold for about $500 per lb., but now the cost of the metal is approaching commercial levels for special applications. As more uses and cheaper processes are found, the price of the metal is almost certain to drop still further. Present uses, although important, do not require tremendous quantities of the metal.

In the manufacture of electron tubes, zirconium serves an exceedingly useful function as a getter. Getters are used in the tubes to absorb those gases which remain in the tubes after they have been evacuated. Nearly every photographic flash bulb contains a tiny quantity of zirconium to assist in the bulb's firing action. Many fluorescent lamps are made more efficient through the use of minute amounts of zirconium.

Another important present use of zirconium is as an alloying element. This use is expected to expand. One of the more recent alloys depending on this metal is a magnesium extruding alloy. Approximately one-half of

A few typical examples of forms and parts made of zirconium. Shown are drawn cups, a screw, wire screen and drawn rod.



1% of zirconium provides the alloy with desirable extruding characteristics and end service properties. Increasing quantities of zirconium are also being used in connection with other metals.

A few years ago the Air Materiel Command instigated research into the development of zirconium-base alloys for possible high temperature aircraft use. Thus far no alloys have been developed which would be useful at high temperatures, although some were found to have good properties up to 1200 F. Of all the alloying materials tried, aluminum was found to serve best in increasing the hot strength of zirconium.

Potential Uses

There are probably many undiscovered uses for zirconium, and companies interested in the metal, such as Foote Mineral Co., are investigating many possible applications. Two uses uncovered by Foote engineers give promise of using moderate quantities of the metal in the near future.

The corrosion resistance of zirconium, plus the fact that it is non-toxic, suggested the possibility of its use in surgical parts and appliances. Investigation by competent medical personnel revealed that zirconium also would permit human tissue to grow to it. Thus, it can be used for bone screws, plates, wire and other parts for use in the human body.

A second large field of use could be in the manufacture of quality jewelry. Zirconium rings will retain their lustre equally as long as precious metals. The chief drawback to the more extensive jewelry use of zirconium today is that zirconium can only be joined by inert gas welding. Most jewelry now made is joined by means of silver soldering. So the adoption of zirconium as a material would mean that manufacturing jewelers would have to learn new manufacturing techniques.

Considerable zirconium metal is used in connection with the atomic energy program for uses that are as yet undisclosed. When and if these uses can be revealed it is likely that they will suggest other civilian uses.

Zirconium has been found quite satisfactory in the making of glass-to-metal seals. The oxide of the metal is soluble in glass. One application using this characteristic would be in the production of glass-lined tanks.

Since repeated or constant exposure to the atmosphere will not affect zirconium in any way, it has been suggested that it be used to make sensitive scientific weights where no loss of weight can be tolerated.

Properties

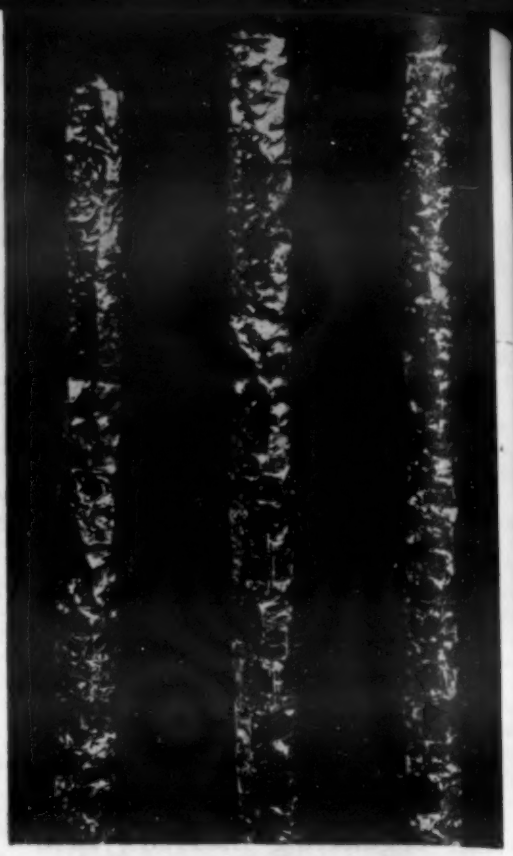
The outstanding quality of zirconium, after its gas absorption, is its resistance to corrosion. With the exception of hydrofluoric acid, most common acids and alkalies have little or no effect upon the metal. Atmospheric exposure does not cause corrosion, nor does the ordinary industrial atmosphere tarnish or discolor the bright surface of the material.

At room temperature, zirconium is moderately strong. However, strength falls off rapidly at elevated temperatures. This fact is true despite a melting point of approximately 3300 F. Annealed zirconium has an ultimate strength ranging from 34,000 to 45,000 psi. and a yield strength ranging from 11,000 to 20,000 psi. With a specific gravity of 6.53 g./cc., zirconium is lighter than iron and steel, and heavier than titanium.

Accompanying tables give the properties expected in the pure iodide type zirconium produced today.

Although zirconium work hardens rapidly, it has great work capacity and can be cold rolled and drawn. Because of its gas sensitivity the metal must always be annealed in a vacuum. It can be welded by the inert gas welding process without the use of filler metal. Machinability of zirconium approaches that of brass. Experience gained up until now shows that zirconium will seize in wire forming dies, so special wire drawing procedures have been developed.

Currently, iodide zirconium is being produced as wire and in sheet, bar and rod in the following sizes: swaged bars—approximately 1/8- to 1-in. dia. by 3 to 6 ft. long; sheet—2 to 4 in. wide by 8 to 16 in. long and 0.002 to 0.010 in. thick; wire—0.003- to 0.040-in. dia.



Crystal bars of zirconium obtained by iodide process. All forms and shapes are produced from such bars.

Physical Properties

Melting Temperature	3375 F
Specific Gravity	6.53 g/cc.
Specific Resistance (OC)	0.512×10^{-4} ohm-cm.
Linear Coefficient of Thermal Expansion	49.6×10^{-7} in./in./deg. C
Transformation Temperature	1584 ±9 F

Average Mechanical Properties

(Iodide metal vacuum annealed 1350 F)

Ultimate Strength, Psi.	34,000-45,000
Yield Strength, Psi. (0.2%)	11,000-20,000
Reduction in Area, %	25-45
Elongation	28-40%
Modulus, Psi. x 10^6	9.0-12.0
Rockwell Superficial Hardness	30T—46 to 59

Corrosion Resistance

(At 212 F)

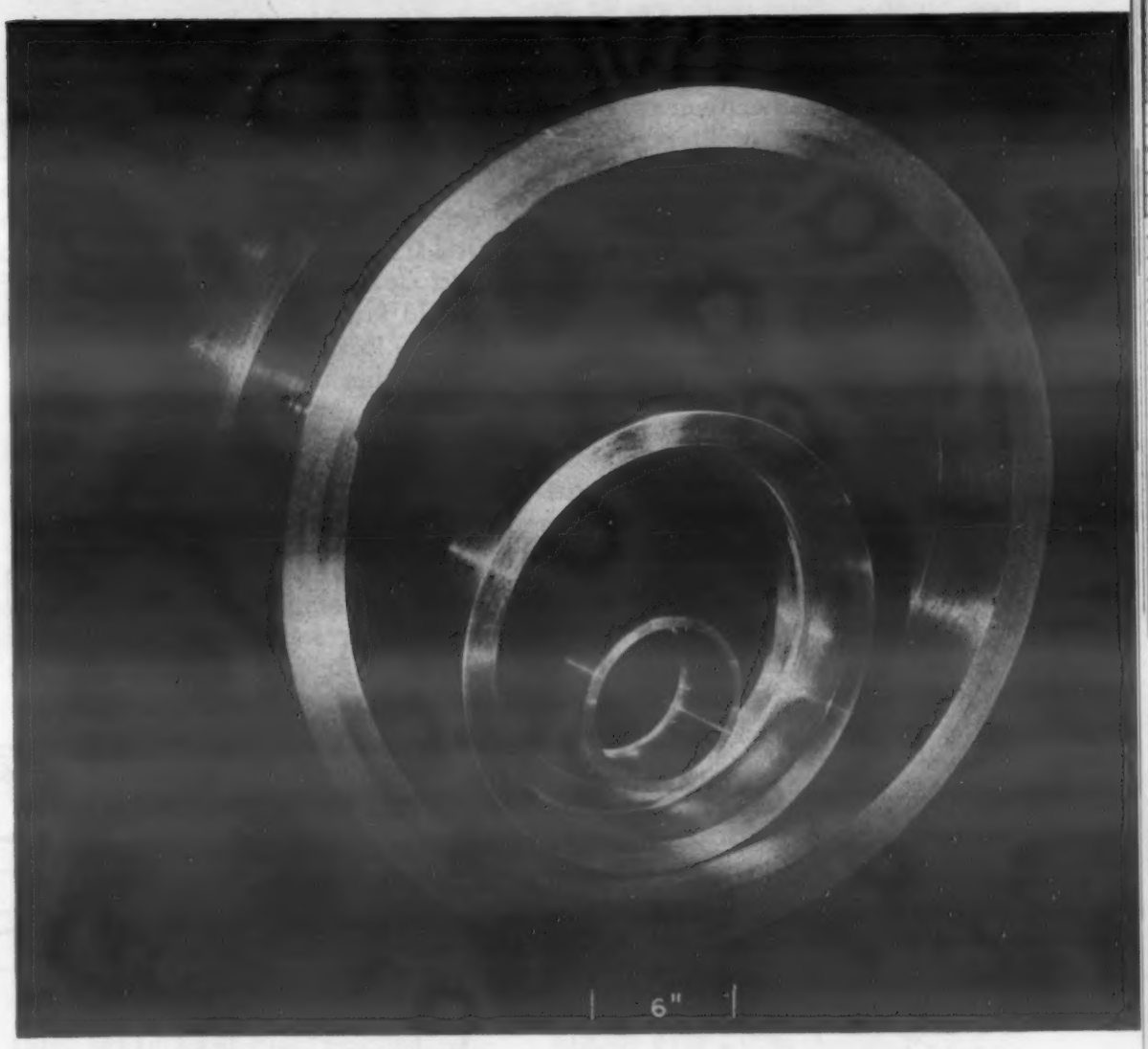
Media	Corrosion Rate In. Penetration per Year
10% Sulfuric Acid	0.0007
Conc. Hydrochloric Acid	0.0002
Conc. Nitric Acid	0.00005
10% Phosphoric Acid	0.00005
10% Sodium Hydroxide	0.00002
10% Potassium Hydroxide	No appreciable attack
20% Sodium Chloride	No appreciable attack
Hydrofluoric Acid (All Strengths)	Rapidly attacked
10% Citric Acid	0.00002
10% Oxalic Acid	0.00004

Specimens 2.5 by 0.5 by 0.005 in. Degreased

Iron-Base Heat Treatable Alloy Has Good High Temperature Strength

by E. F. LOSCO, Materials Engineering Dept., Westinghouse Electric Corp.

Originally designed for gas turbine disks, Discaloy has found use for many other high and room temperature applications.



Shown here are several sizes of high-strength, nonmagnetic retainer rings fabricated from Discaloy by mandrel forging or rolling.

• IN RECENT YEARS, the aviation gas turbine industry has made real progress along the lines of improved performance, greater efficiency and longer life of jet engines that power modern military aircraft. The development of new and improved alloys capable of withstanding high service temperatures and stresses for extended time periods has greatly contributed to this progress. One of the latest alloys which falls in this category is Discaloy, produced by Westinghouse Electric Corp.

Discaloy was originally designed to meet the need for improved gas turbine disks, one of the most critical components of jet engines. It has exceptionally high creep strength, combined with good ductility and excellent oxidation resistance in the temperature range 1000 to 1350 F—the range in which gas turbine disks operate. The alloy's high resistance to plastic flow has made it possible to materially reduce the weight of gas turbine disks, and thus improve the performance and efficiency of jet engines without sacrificing life. Other features make the alloy not only outstanding among competitive disk alloys, but also useful for a variety of both low and high temperature applications.

Discaloy is an iron-base alloy consisting of about 55% iron. It contains none of the relatively scarce and strategic elements—columbium, cobalt and tungsten. But its combination of creep strength and ductility in the temperature range 1000 to 1350 F is comparable to, and in many cases surpasses, that of several heat resistant alloys much higher in alloy content. Nominal composition is given below:

Iron	54.0%
Nickel	26.0%
Chromium	13.5%
Molybdenum	3.2%
Titanium	1.6%
Manganese	0.7%
Silicon	0.8%
Aluminum	0.1%
Carbon	0.03%

With the exception of Discaloy, all commercial alloys that are presently used for aviation gas turbine disks depend on cold work for their strength. Discaloy, on the other hand, derives its strength through heat treatment. This makes it possible to attain uniform properties in various sections of forgings despite wide variations in size and shape. It has permitted the establishment of guaranteed minimum strength properties considerably higher than those speci-

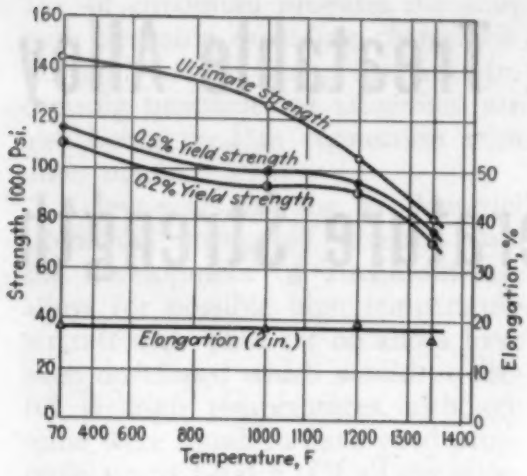


Fig. 1—Graph gives short-time tensile properties for a Discaloy gas turbine disk forging.

fied for disk alloys that rely on "hot cold work" to develop high strength.

Attainment of properties through heat treatment rather than cold work has other distinct advantages. It simplifies the forging operation, since working can be carried out at relatively high temperatures where formability is high. Smaller size forging equipment can be used to fabricate parts that normally require much larger equipment when made from non-heat-treatable alloys. Large forgings having intricate shapes can be fabricated with relative ease in closed dies with attendant savings in material and machining costs. For "hot cold work" alloys, on the other hand, the amount of contouring that can be done is limited to simple shapes even when the largest available forging hammers are used.

Applications

Discaloy is suitable for many applications where high strength is required at all temperatures up to 1350 F. Its uniformity of properties, forgeability, and machinability make it especially desirable for large forgings having complicated shapes. Its low magnetic permeability, coupled with high strength and oxidation resistance, permit its use in many applications where magnetic alloys, of both low and high alloy content, cannot be used without serious losses in equipment efficiency and performance.

The alloy is used for many gas turbine components where stability under high stresses and temperatures are prime requisites. These include disks, bolts, couplings, spacer rings and extension pieces. Discaloy in the form of sheet is now being considered for other components of gas turbines. Steam turbine components, such as throttle valves that operate at temperatures up to 1050 F, have also been made from the alloy.

Discaloy is used in turbo generator rotors and other electrical equipment such as coil retaining rings that require high strength as well as nonmagnetic characteristics. By replacing the formerly used high-strength magnetic steels with this alloy, power losses have been reduced and efficiency improved. Because of the relative ease of fabrication and machining, this application of Discaloy has simplified manufacturing operations and reduced costs. Retaining rings up to 27 in. dia., weighing approximately 700 lb., have been made. Larger rings can be made and are contemplated for newly designed power units.

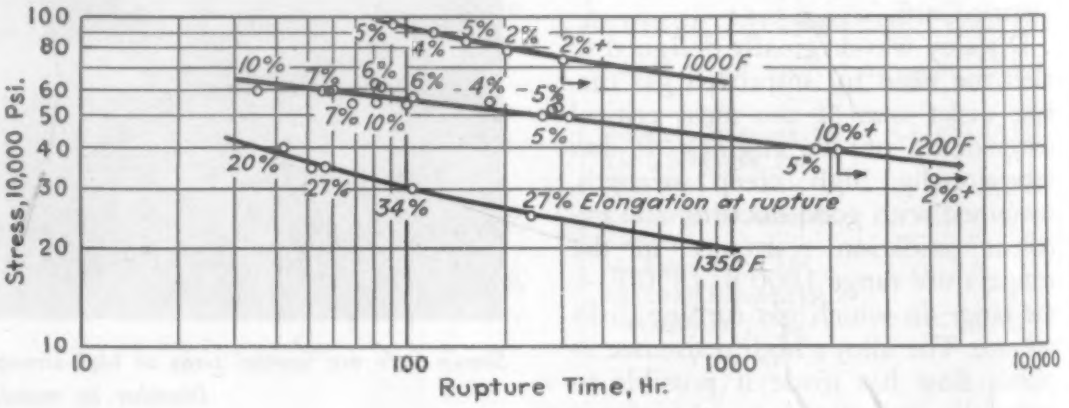
Extrusion dies made from Discaloy, slightly modified in composition to produce exceptionally high hardness and strength, have, in some instances, replaced high alloy tool steels because of longer life and greater wear resistance. Hot work tool steel dies — 15 tungsten, 3 chromium, 0.5 vanadium and 0.5% carbon — formerly used to extrude Phos-Copper wire at 1050 F would fail by cracking after 5000 to 10,000 lb. of wire had been extruded. These dies required regrinding, because of wear, after extruding 3000 lb. of wire. In comparison, Discaloy dies now used for this application have extruded over 30,000 lb. of Phos-Copper wire with approximately one-fifth the wear and are still in operation without a single failure. Because of the greater stability of the alloy at elevated temperatures, it has been possible to increase the extrusion temperature from 1050 to 1275 F. After more than 2000 hr. at the higher extrusion temperatures, the Discaloy dies have shown no loss in hardness or strength.

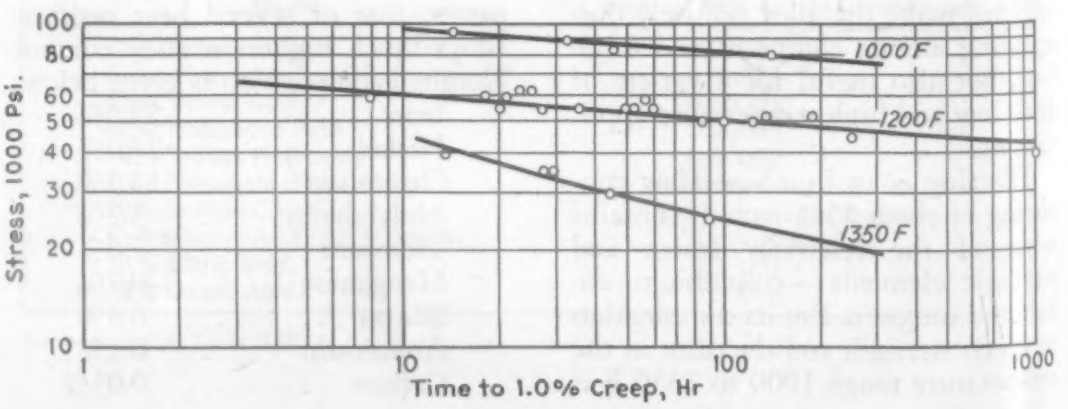
High-strength Discaloy has also been used as a spring material at room temperature and slightly elevated temperatures. Belleville springs made from this alloy have been substituted for 17 chromium, 7% nickel cold-worked stainless steel springs in mercury-arc rectifiers. Test data indicate that the spring qualities of Discaloy are equivalent to, or better than, those of the cold-worked alloy, and service performance has been entirely satisfactory. The alloy is expected to be useful for other spring applications in both wire and sheet form at temperatures up to 1200 F.

Properties

The density of Discaloy is 0.287 lb. per cu. in. and its melting range approximately 2550 to 2600 F. Its magnetic permeability is 1.008, comparable to that of annealed stainless steels; this remains essentially constant despite drastic cold work, extended holding times at elevated temperatures, or cooling to liquid helium temperatures. Discaloy is completely austenitic under all conditions of fabrication and heat treatment.

The linear coefficients of expansion, elastic moduli, and fatigue properties are listed in Table 1 for a wide range





Figs. 2 & 3—These stress-rupture and creep curves apply to gas turbine disk forgings.

of temperatures. The values given are for material machined from fully heat-treated gas turbine disks and are representative of the alloy. The low coefficients of expansion are important in minimizing stresses in parts subjected to wide temperature variations. The high moduli, which vary linearly with temperature, indicate high rigidity at both 70 and 1200 F.

The hardness of Discaloy in the solution heat-treated condition ranges between 130 and 170 Bhn. The hardness of fully heat-treated material depends on hardener (titanium) content. For gas turbine disks, the hardness may vary from 248 to 302 Bhn., depending on whether the titanium content is on the low or high side of the specified range. These ranges of titanium content and hardness are closely adhered to in gas turbine disk forgings in order to realize optimum creep-rupture properties. In the case of forgings that require exceptionally high tensile strength, the hardener content is increased. Hardnesses between 302 and 400 Bhn. are used for such forgings, depending on specific property requirements.

The variation of short-time tensile properties with temperature for a representative Discaloy gas turbine disk forging having a hardness of 293 Bhn. is shown graphically in Fig. 1. The room temperature ultimate strength is 145,000 psi. At 1200 F it is well above 100,000 psi. The yield strength at 0.2% offset decreases gradually with temperature, being well over 85,000 psi. at 1200 F. Ductility, as indicated by elongation values, is close to 20%, and remains high over the entire service temperature range.

Variations in tensile properties in different sections of a given forging are small, but some variations must be expected in forgings made from different heats. Statistical analysis has shown that about 95% of the heats processed into gas turbine disk forgings will have tensile strength over 130,000 psi., a 0.2% yield strength over 85,000 psi., and elongation over 15%. These are considered minimum tensile properties, and are specified and guaranteed for the forgings. Average values are 136,000 psi., 95,000 psi. and 20.5% for tensile strength, 0.2% yield strength and elongation, respectively.

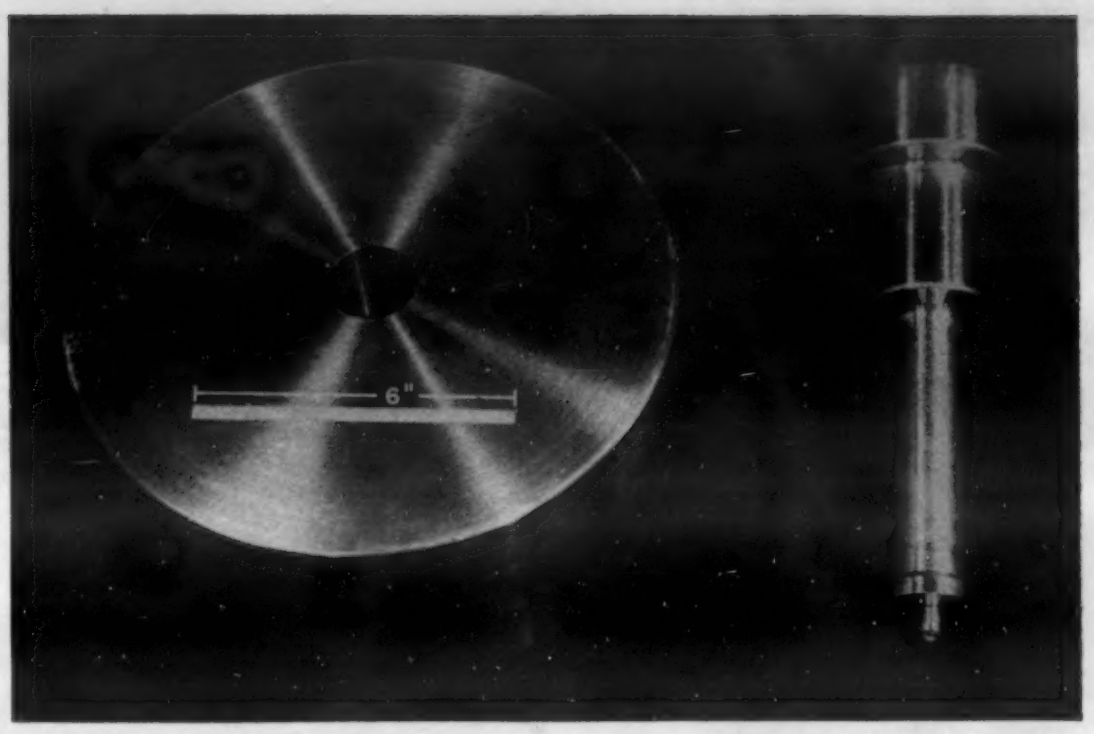
Forgings requiring high tensile strength combined with low magnetic permeability have been fabricated from material having a hardness range of 321 to 363 Bhn. The 0.2% yield strength of this material is specified as 125,000 psi. minimum at 500 F. Values as high as 140,000 psi. have been obtained at this temperature with ultimate strengths of 160,000 psi. and elongations of 10 to 15%. As was shown for gas turbine disk forgings, the high yield strength does not markedly decrease until temperatures above 1200 F are reached.

Stress-rupture and creep properties of Discaloy are illustrated in Figs. 2 and 3. Hardness of these disk forgings was 293 Bhn., and the close fit of the plotted points to the average curves is indicative of the high degree of uniformity of creep-rupture properties. Ductility, which is necessary in gas turbine disks to give warning of impending failure, is considered to be entirely adequate.

In the case of gas turbine disks, creep-rupture properties for time periods up to 500 or 1000 hr. are of prime importance. The creep rate must be low at design stresses to avoid interference of assembled blades to covering shrouds. The high creep resistance of Discaloy is illustrated by the results of a test run at 1200 F and 35,000 psi. Under these conditions the minimum creep rate was 1.11 x 10^{-4}% per hr. At 1000 hr. the total creep strain was only 0.21, the test being stopped at the end of 3839 hr. when the total creep strain was slightly over 2.0%.

The distribution of creep-rupture properties in disk forgings made from different heats has been established on the basis of tests conducted at 1200 F and 60,000 psi. The average rupture time and elongation are 22.0 hr. and 7.8%, respectively. Minimum specified and guaranteed values are 10.0 hr. and 5.0%.

Another factor of prime importance in gas turbine disks is the sensitivity of the material to stress concentrations produced by drilled holes and small radii such as those machined at the disk periphery for attaching blades. Comparison of the creep-rupture strength of notched and un-

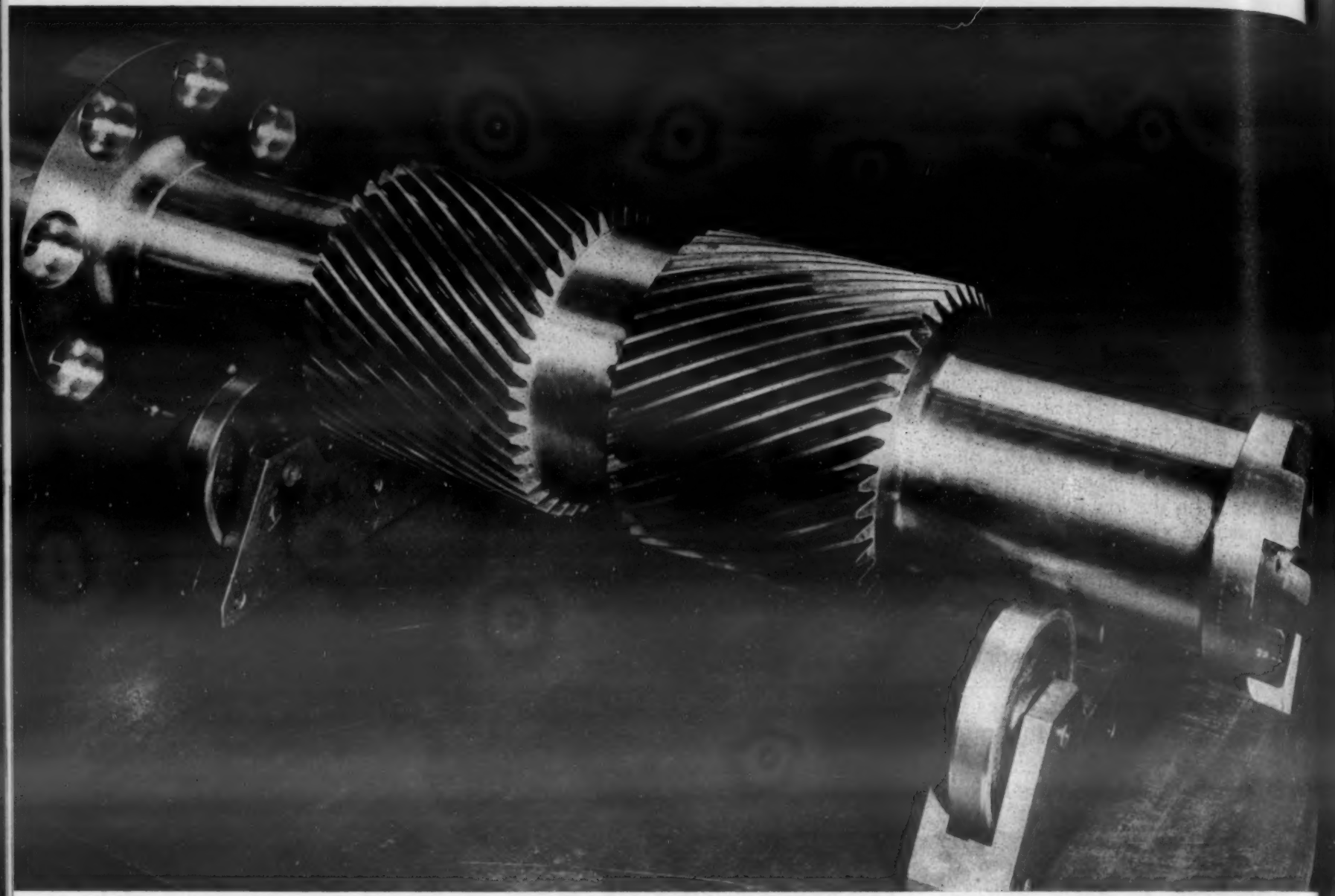


Discaloy die and plunger are used for extruding Phos-Copper wire at temperatures of 1200 to 1275 F.

Table 1—Properties of Discaloy at Various Temperatures

Temperature, F	Linear Coefficient of Thermal Expansion (In./In./deg. F)[1]	Tension Modulus of Elasticity, 10^6 Psi.	Fatigue Strength, Psi.[2]	
			10^6 Cycles	10^8 Cycles
70	8.4	28.4	67,000	56,000
200	8.5	27.6	—	—
400	8.7	26.4	—	—
600	9.1	25.0	—	—
800	9.4	23.5	—	—
1000	9.5	22.3	—	—
1200	9.6	21.0	59,000	50,000
1350	9.8	20.0	—	—

[1] *Coefficients are for temperature range from 70 F to temperature indicated.*
[2] *Cantilever test bars subjected to repeated bending at a frequency of 7200 cycles per min.*



Machining operations on this pinion forging were performed on fully hardened Discaloy with standard tools and equipment.

notched Discaloy bars indicates that the alloy is unusually strong in the presence of notches. Creep-rupture strength is actually raised at both 1000 and 1200 F when notches having a stress concentration factor of 3.9 are machined in specimens.

Notches also tend to raise the short-time tensile strength of Discaloy. Tensile tests on bolts indicate that failure takes place in the threads and that the room temperature yield strength at 0.2% offset, based on the area at the base of the threads, is above 110,000 psi. This is consistently higher than that obtained for unnotched bars. Considerable deformation, indicating substantial ductility, is observed in the threaded area after test.

The oxidation resistance of Discaloy at 1500 F is comparable to that of K42B and Refractaloy 26. These alloys, which are cobalt-nickel-chromium base, contain about 20% chromium and are used for service applications involving temperatures considerably higher than those recommended for Discaloy. At temperatures above 1500 F, the latter alloys are more resistant to oxidation, but below this temperature all three alloys show negligible attack. At 1500 F, for example, the depth of oxygen penetration of Discaloy heated in air for 500 hr. is about 0.00005 in. At temperatures up to 1350 F only slight discoloration is observed for prolonged heating times. The alloy will not scale at forging temperatures as high as 2150 F.

Fabrication, Heat Treatment

The forging characteristics of Discaloy have been compared with those of medium-carbon steel, 18:8 stainless steel and K42B under controlled test conditions. Sample bars of each material were upset under a 1000-lb. steam board drop hammer and the change in height measured for single hammer blows at a series of temperatures. By plotting the change in height versus temperature the relative forgeability of each material was established (see Fig. 4).

Discaloy, because of its higher strength at elevated temperatures, is more resistant to deformation than medium-carbon or 18:8 stainless steel. Compared to K42B and similar heat resistant alloys, it is much easier to forge and is less susceptible to cracking. Its forgeability rises rapidly at temperatures above 1800 F, and at 2150 F it is about equal to that of 18:8 stainless steel at 1970 F.

Discaloy can be forged over a wide temperature range, 1600 to 2300 F. Because of its relatively high formability, however, it is not necessary to employ extremely high temperatures. The recommended hot forging range is 1800 to 2150 F. The upper part of the range is used for initial operations on large forgings while the lower part is used for final operations and for small sections. Hot rolling is carried out in the same temperature range.

The relatively high degree of formability of Discaloy is reflected in the numerous methods used to fabricate parts. Gas turbine disks of relatively small diameter are upset forged into pancake shapes and the final disk configuration is machined from the pancake. Relatively large diameter disk forgings have also been made

in this way. When the latter entail considerable machining to produce an intricate shape, pancake forgings result in material waste, and contour forging in closed dies becomes desirable. Under emergency conditions, when forging costs are secondary to the saving of even the less critical alloying elements, high-strength alloys that are capable of being contour forged to intricate shapes take on added importance.

Another method of fabrication that has been used to save material and cut down machining costs is tire rolling. This method has been successfully used to fabricate seamless rings of various sizes and shapes. Tire rolling of Discaloy is performed at elevated temperatures where formability is relatively high. Rolling of rings, which has distinct advantages over mandrel forging, cannot be employed for alloys which require cold work to attain high-strength properties. Rings can be tire rolled much closer to finish machined dimensions than is possible by mandrel forging. To a limited extent, flanges and other projections can be tire rolled as an integral part of the ring. Such changes in cross sections are impractical for mandrel forgings, which must be machined with considerable metal loss. Tire rolling has another advantage in that the metallurgical structure of the part is improved by locating flow lines in the most desirable direction. This is also true of contour forging.

For small parts, production costs can be appreciably reduced and material savings realized if cold-forming operations can be substituted for machining. This can be done in the case of Discaloy bolts and studs. Bolt heads are upset at room temperature using cold-drawn bar stock as a starting material. Threaded sections of bolts and studs are cold rolled. After heat treatment the strength properties of these bolts are high and uniform.

All types of machining operations can be performed on Discaloy using standard high-speed steel and cast alloy cutting tools. Cemented carbide tools have also been used, but in most cases are not necessary. Final machining is usually done when the material is in the fully hardened condition to obtain a smooth surface. Such difficult operations as drilling, milling and broaching are performed on a production scale with relative ease. Longer tool life and more rapid machining will be realized for hogging cuts greater than ¼ in. deep or interrupted cuts when the material is in the as-forged, solution heat treated or partially aged condition. Surface smoothness, however, is sacrificed if machining is done when the material is in the soft condition. Discaloy can

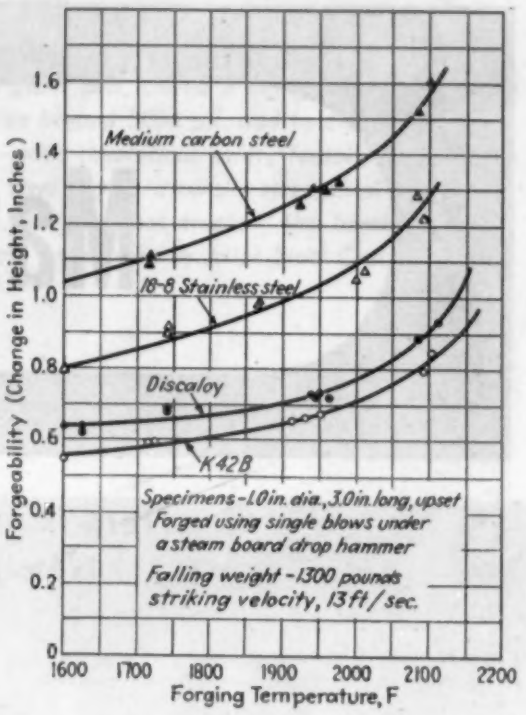
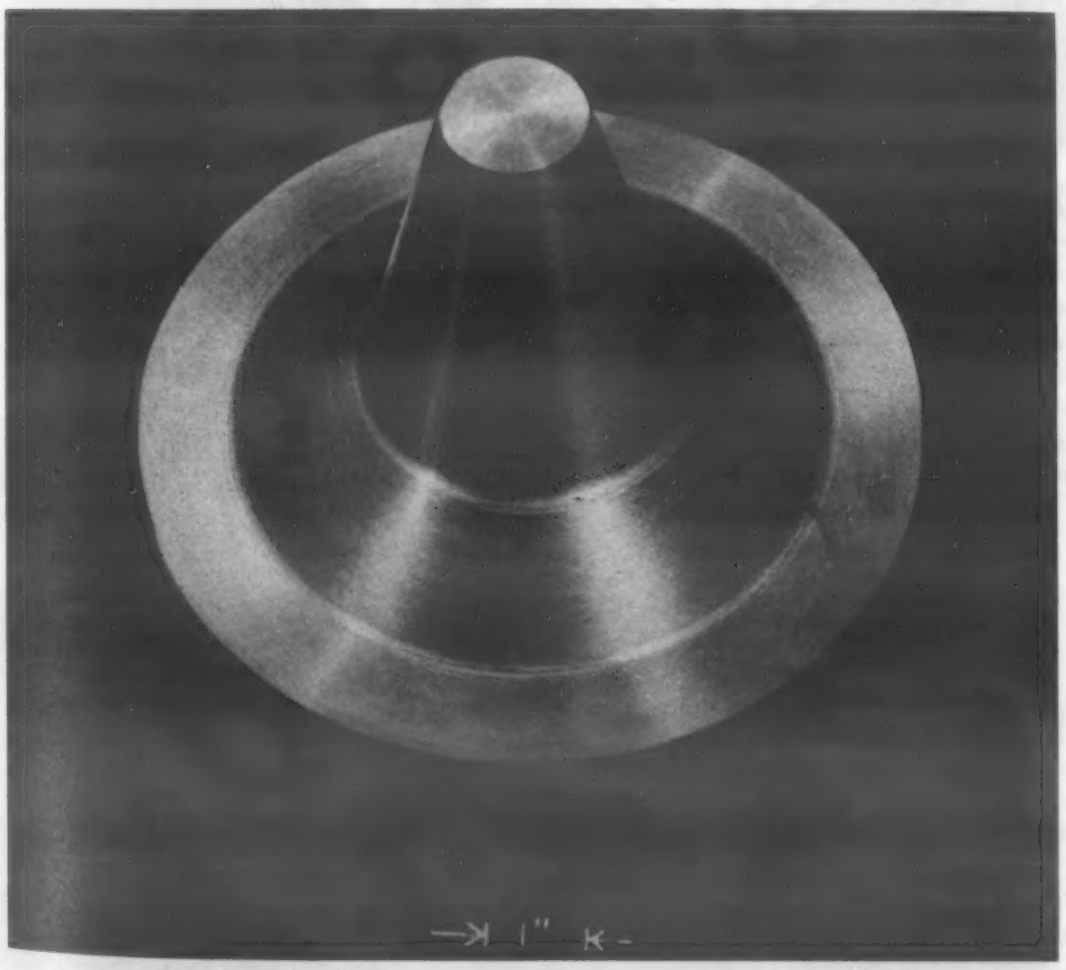


Fig. 4—Curves show relative forgeability of various materials as affected by temperature.

be readily cut in either the soft or hard condition with abrasive wheels, power hack saws or, in the case of sections 2 in. or less in thickness, with band saws.

Experience in production welding of Discaloy is limited. Where welding has been used, however, no unusual difficulties have been encountered. Discaloy rods up to 1.0-in. dia. have been flash butt-welded successfully to SAE 4130 steel. Discaloy sheets have been joined successfully by spot, seam and inert-arc welding. Experiments are now under way to obtain more complete welding information, especially as it applies to the properties of welded sheet.

Discaloy is heat treated in two separate operations. The first involves solution treating by holding 1 to 2 hr., depending on the size of the part, at 1800 ±25 F followed by oil or water-quenching. This treatment places the hardening constituent in solid solution and relieves all prior working stresses. In this condition the material is quite soft, 131 to 170 Bhn., and amenable to forming and other operations. The second operation involves precipitation hardening or aging. The material is held 20 hr. at 1350 ±15 F, furnace cooled to 1200 ±15 F, and stabilized by holding 20 hr. at the latter temperature. This heat treatment results in full hardness that is dependent, as previously indicated, on hardener content. When fully heat treated, the hardness and strength properties of Discaloy are stable over the entire service temperature range.

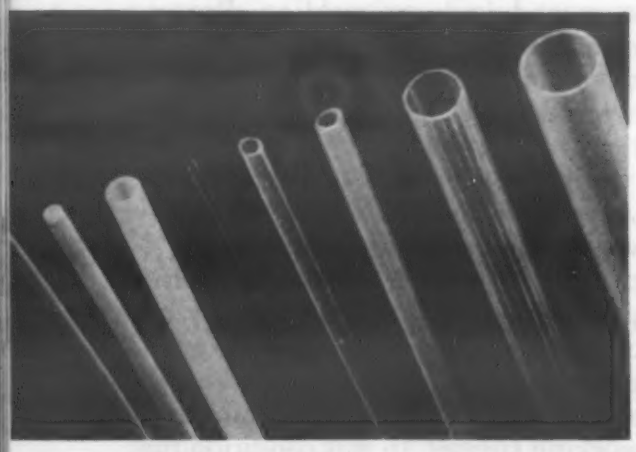


This extension piece is one of many gas turbine components made from Discaloy.

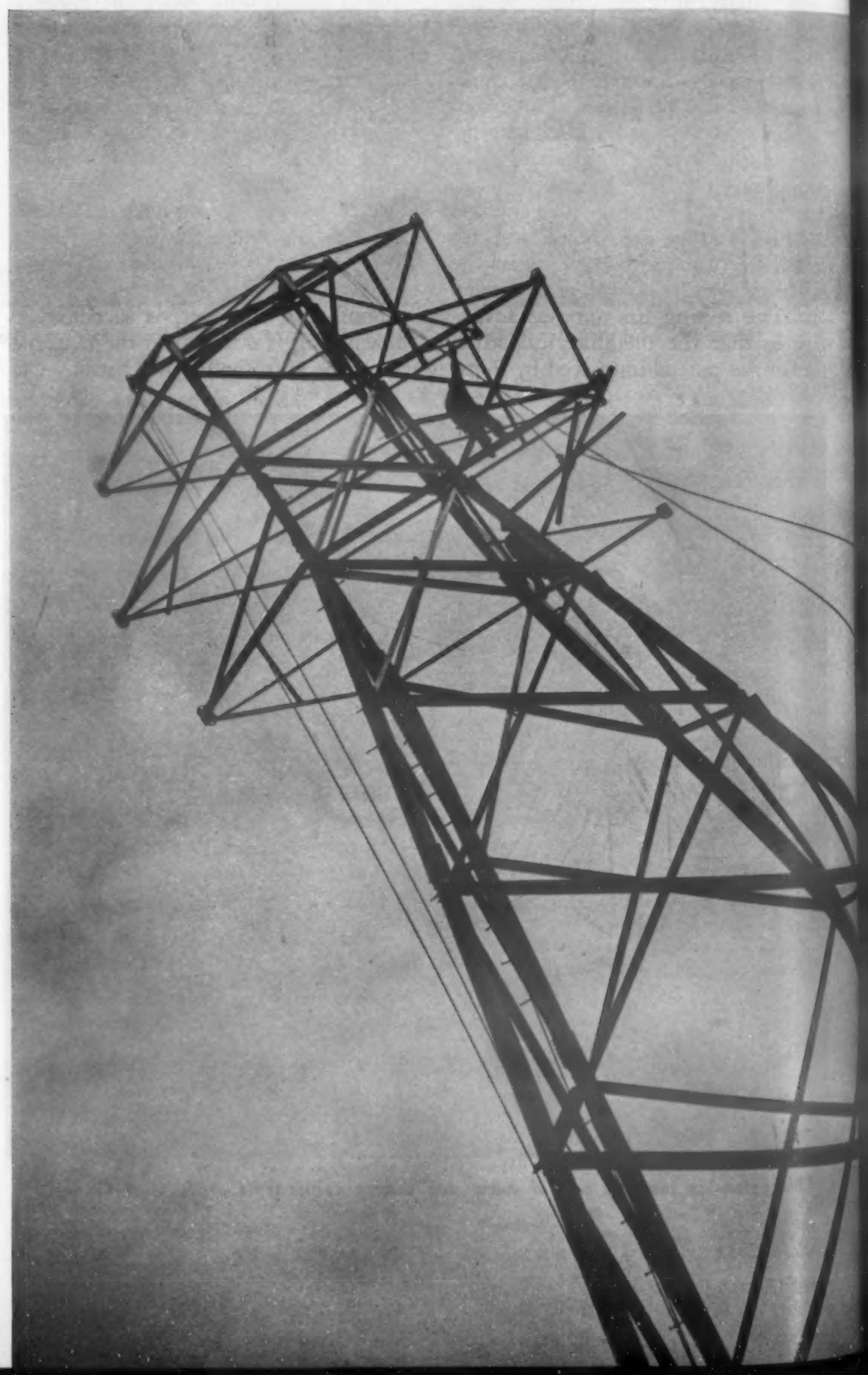
Materials at Work

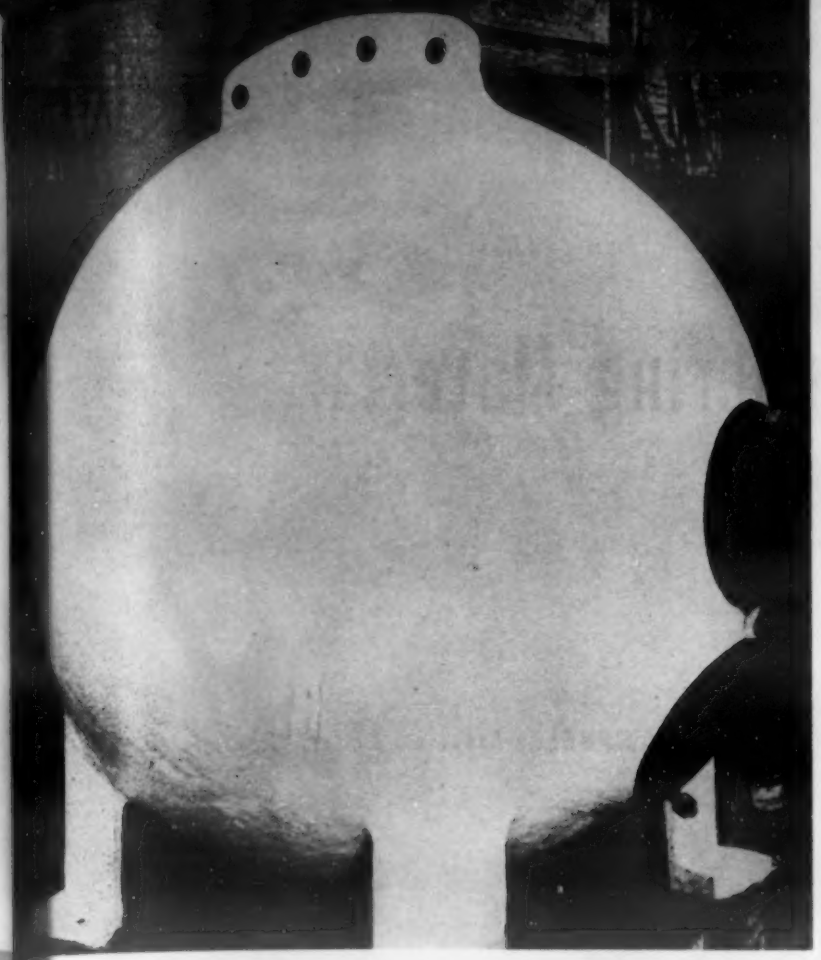
Here is materials engineering in action . . .
New materials in their intended uses . . .
Older, basic materials in new applications . . .

ALUMINUM CROSSARMS *What is believed to be the first installation of aluminum crossarms on standard steel transmission towers has been completed on the Duquesne Light Co.'s Phillips-North line near Ambridge, Pa. Approximately 24,000 lb. of Alcoa aluminum alloy 61S-T6 structural angles were used for the crossarms on 14 suspension and seven strain towers. Because of the alloy's excellent corrosion resistance, it was not necessary to apply a protective coating to the crossarms, thus eliminating the usual shut-down of the line for painting. (Courtesy Aluminum Co. of America)*



PLASTIC TUBING *This array of plastic tubing and rods produced by Plax Corp. represents only one of the many uses of KEL-F, a fluorocarbon-type plastic. KEL-F is available from M. W. Kellogg Co. in both high and low density molding powder, and in the form of oils, greases and waxes in addition to the plasticized form. Retaining satisfactory properties over a wide (−320 to 390 F) range, this versatile plastic has been used to coat wire, for gaskets, valve diaphragms, collapsible bags, condenser foil and a wide variety of other applications in the chemical and electrical industries.*

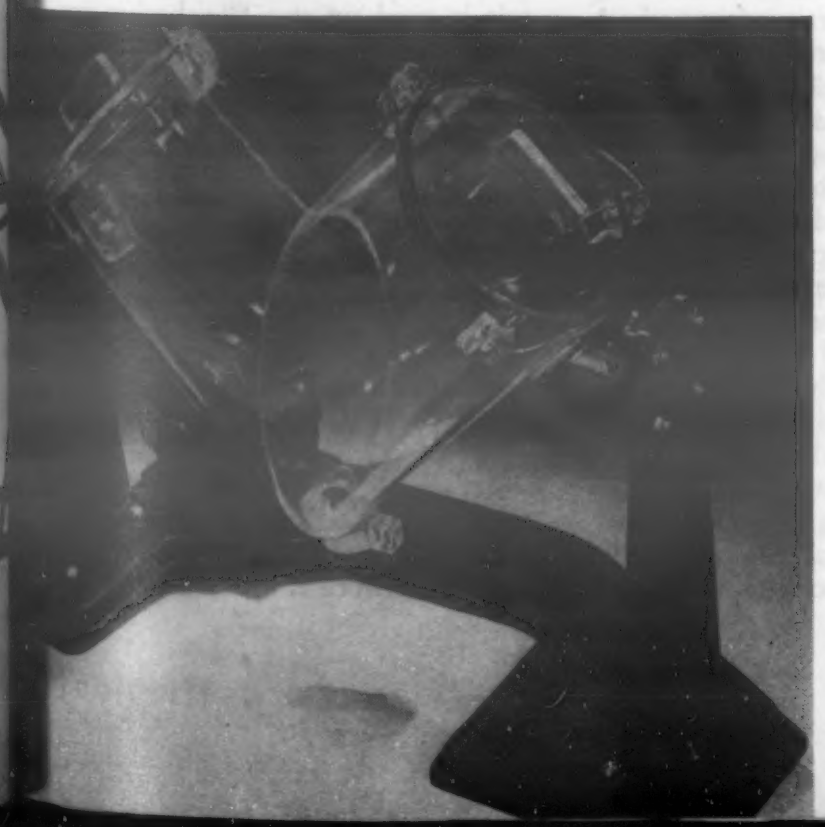




CAST STEEL BENTHOSCOPE *Otis Barton, Boston scientist, has undertaken mile-deep undersea explorations in this odd-looking, cast steel diving bell. The giant bell, called a benthoscope, is designed to withstand pressures beyond 3000 psi. and to descend to a depth of at least 6000 ft.—with theoretical safety factors down to 10,000 ft. Cast in an alloy steel having a tensile strength of 90,000 psi. and yield point of 70,000 psi., heat treated, the benthoscope shell and its "manhole cover" were made by Atlas Steel Casting Co.*

STEEL-HUBBED ALUMINUM GEARS *An aluminum body with a bonded-in steel hub makes this Chevrolet camshaft timing gear lighter and quieter in operation than molded resin or fiber gears, but able to withstand much heavier loads. Made of an aluminum alloy bonded to steel with a molecular process developed by the Al-Fin Div. of the Fairchild Engine & Airplane Corp., these gears have a tensile strength of 15,000 psi. The bond has remained intact in shear tests up to 98,000 psi.*

TELEVISION MIRROR *A Westinghouse Electric Corp. scientist examines a clear glass sheet destined to become a mirror that reflects only one color at a time—red, blue or green. After the large wire-enclosed jar (at top) is lowered, sealed and evacuated, evaporated metal compounds are condensed on the surface of the glass. Both the thickness and number of layers deposited on the glass determine which color is reflected. The mirrors are used at both the transmitting and receiving end of experimental color television apparatus.*



LABORATORY DRY BLENDER *Cylindrical shells of Plexiglas, fused together at right angles to form a V-shaped barrel, constitute the basic unit in this new dry blender manufactured for laboratory use in the process industries. Design engineers of the Patterson-Kelly Co., Inc. selected the acrylic plastic for the barrel because of the following desirable features: (1) complete visibility of the blending process, (2) lower production costs in forming the plastic, (3) freedom from corrosion, contamination and discoloration, and (4) ease of cleaning.*

Felt Has Wide Use as Engineering Material

This article tells where and how felt can be used in industrial applications and describes factors that must be considered in selecting the proper type and grade.

by JOHN B. CAMPBELL, Associate Editor, Materials & Methods

It has been pointed out in an earlier article that the peculiar properties of wool felt make it a useful material for a wide variety of engineering applications. In that article (MATERIALS & METHODS, Aug. 1950, p. 47), emphasis was placed on the general characteristics of felt and the physical and chemical properties of standard types and grades.

This article will describe the range of industrial applications for felt, and discuss the factors which should be considered in selecting the proper felt for a specific use. Applications to be covered include polishing and grinding, rubbing and wiping, clutching and braking, backing and cushioning, vibration isolation, sealing, wicking for lubrication and feeding liquids, filtering air and liquids, and thermal and sound insulation.

Felt Selection

The most important thing to remember in felt selection is that the felt industry is primarily a custom industry. An engineer who knows only that some type of felt might do the job can be reasonably confident that the felt manufacturer will recommend and produce the proper material for his specific application. In some cases the problem will be complicated enough to require a great deal of experimentation in felt research laboratories. But the principal uses for felt have become so well established that, in many cases, the felt manufacturer can supply the correct type and grade merely on the basis of past experience.

Unfortunately, expert advice is not always available as quickly as the engineer needs it; the man who selects materials, consequently, must become something of an expert himself. The information presented in this article and the previous one will enable the materials engineer to select a suitable felt for most routine applications. At the same time, the discussion should serve as a useful guide to the solution of more difficult felt selection problems. Wherever possible, however, the aid of the felt manufacturer should be enlisted.

In practically every case, the problem of felt selection boils down to two questions: What density? What quality? It is true that for filter felts permeability and cost are of primary importance, and for wicking uses delivery rate is most vital, but all of these characteristics are related to density and fiber mix.

Generally, density is determined by the physical properties required. A certain amount of resistance to deformation or a specified absorption capacity fix the density. Correct fiber mix depends upon several factors. In some cases, fibers other than wool are used to provide a definite combination of physical properties not otherwise obtainable. Generally, however, the two most important factors are chemical purity and cost. Whiteness can be achieved only in the highest grades, and in food processing machinery it is often desirable to have a felt with minimum chemical adulteration. For sealing purposes, however, high residual oil content would obviously be unimportant and lower grades could be used. As to cost, it need only be said that the higher the percentage of virgin wool, the more expensive the felt. As usual, the materials engineer must hit a satisfactory compromise between best performance and minimum cost.

Friction Uses

The hardness and toughness of the denser felts make them good friction materials. Thus, felt is particularly useful in polishing or wiping metals, glass and other materials, and in certain clutching or braking applications.

The type of felt selected for various polishing and grinding operations varies with the material being worked and the severity of service required. For instance, the removal of rust and stains from saw steel requires a coarse, hard hair felt composed of cattle hair. An equally hard, though somewhat less coarse Mexican sheet felt is used on the Weisbecker machines which polish metal plates.

Although felted wool fibers are suitable for polishing under certain conditions, in other cases felt wheels serve as carriers for liquids in which abrasive substances are suspended. An example is the Spanish sheet felt strip inserted in a metal channel and used to polish metal cylinders. However, most felt wheels are "set up," *i.e.*, coated with glue and rolled in selected grits to provide a permanent abrasive tool. Set-up felt wheels are more resilient than conventional grinding wheels, such as emery and carborundum, and, therefore, provide more uniform cutting action. Rotating

A lubricated layer of fine wool felt cushions the Plexiglas sheet during vacuum forming in this die. (Courtesy Swedlow Aeroplastics Corp.)

Spanish sheet felt rollers with fine pumice are used to polish cutlery. Propeller blade polishing calls for precision work, and an extra-hard Mexican sheet felt is used as a base for carborundum abrasives.

Glass polishing involves a phenomenon somewhat different than the "cutting down" in metal polishing. The polishing wheel develops enough frictional heat over a rather limited area of contact to cause kneading and surface flow of the glass, completely healing scars of minute depth. Thick felt mounted on wheel surfaces is used to eliminate defective scratches on plate glass; special scratch wheel densities are available in either Spanish or Mexican grades. Production polishing of plate glass calls for a hard, coarse hair felt which absorbs and holds rouge polishing compounds and has long life.

In polishing methyl methacrylate plastics (Plexiglas, Lucite), a fine fiber felt is needed for a scratch-free finish, and the slightly softer back checks are preferred over sheet felts. Such wheels, used with glass-producing polishing compounds on umbrella handles and novelties, have saved considerable time compared to cotton buffs.

For less severe polishing operations and various wiping jobs, less dense felts are required. Wiping brass or steel strip free of grease and dirt calls for a hard, durable material, but not necessarily as coarse as a polishing grade. Usually a medium-weight grey sheet felt or a back check is used. Back checks are common for many of these wiping operations, typical applications including: cleaning chromium plate in automotive grills, which is often contaminated with body paint; cleaning metal strips prior to plating, as in the silver plating of cutlery; and cleaning out tubing by means of felt plugs lubricated with wax compounds and blown through by compressed air.

There are other frictional uses for felt. For instance, felt facings are often used as clutches for changing speeds, providing cushioning and smooth, silent operation. This service requires a medium-weight grey sheet felt which resists surface glazing. Back checks are used as "tensioning" surfaces for cloth or thread windings. Felt rolls are also used to grip skins in stretching or smoothing of leather. The choice here is a Spanish or other sheet felt which retains gripping characteristics when wet.

Cushioning

Everyone is familiar with the use of felt in packaging such items as chinaware, radios and precision equipment. Felt is easily molded to fill in recesses, and it protects corners and highly polished surfaces. In packaging, low-cost cotton-mixed linings and soft pads are used, but a wide variety of felt materials are used in other cushioning applications, depending upon the particular conditions involved.

A special line of "window channel" felts has been developed for automotive uses and for store fronts, lamp rims, etc. In automobiles, felt quality must be such that the vinyl sheet inserts of safety glass are not stained, and the felt must have a low coefficient of friction, wet or dry. Sometimes channel felts require special impregnations. Another common use for felt in automobiles is in nonsqueak washers or strips between chassis and body. Soft pads are used,

Felt composed entirely of natural white wool is specified for this compact engine oil filtration unit manufactured by General Filters, Inc.

sometimes with special impregnations for moisture resistance or other properties.

The particular requirements of cash carrier heads have also resulted in a special line of materials designed for this use. Not only must the felt act as a bumper to absorb shock but as a washer to seal against loss of air pressure in the tubes. A firm felt with good splitting resistance, long life and dimensional stability is required.

Undoubtedly one of the most important cushioning applications of felt is vibration isolation. Felt can be used to absorb some of the impact of punch presses and drop hammers or the vibration of textile looms and printing presses. It can also be used to protect delicate machinery and instruments from the effects of vibrations present in manufacturing buildings.

Several felt manufacturers have made detailed studies of vibration isolation. A typical selection guide, based on felt 1 in. thick, is given below:

Load, Psi.	*Felt Type*	*Density*
1-6	F-11	18
6-12	F-6	26
12-25	F-2	34
Over 25	Hair	55

Although this guide can be used for most applications, in unusual cases it is suggested that these general recommendations be checked by theoretical design formulas and actual computation. Such data are available from the felt industry.

Felt is used in the cowling support rings of this airplane engine installation. It dampens vibration and keeps metals from wearing against each other. (Courtesy The Felt Assn.)

Sealing

In sealing applications felt serves one or both of two purposes: (1) to retain oil or grease, and (2) to exclude dust, fumes and moisture. In general, felt can be used for operating temperatures from −60 to 250 F where peripheral shaft speeds do not exceed 2000 fpm.

Felt is a good sealing material primarily because of its resiliency, low coefficient of friction and high liquid absorption capacity. Resiliency enables it to maintain constant sealing pressure regardless of wear or end-play and minor misalignment in a shaft. The coefficient of friction, which averages 0.22 for dry felt against steel, is reduced to 0.15 when felt is pre-saturated with oil of 41.2 Saybolt viscosity. Oil storage capacity varies with both felt density and oil viscosity; for any given oil, of course, absorption capacity is lower for denser felts.

There are two broad types of sealing felts—plain and laminated, either of which can be impregnated. Usually both types of material are presaturated with a lubricant of slightly greater viscosity than that used in the bearing. Thus, not only does the seal provide positive bearing protection, but it also serves as a reservoir for excess lubricant, making it available as needed. If the seal is run dry, it tends to polish rather than score the shaft, and it never completely fails through aging, embrittlement or disintegration.

Under normal bearing temperatures and operating conditions, the plain felt seal is highly economical and need be replaced only when the machine is completely overhauled. However, plain felt is not recommended for oils of extremely low viscosity nor to retain pressurized lubricants. For such applications, laminated felts, or sometimes impregnated felts, should be considered.

The laminated felt seal consists of plain felt covered by an impervious membrane of 1/64- to 1/32-in. sheet Hycar or other oil-resistant elastomer. The rubber covering prevents leakage of low-viscosity lubricants. Multiple laminations can be built up for special uses; for instance, the rubber mem-

brane might be used between two different felts—one to retain oil, the other to exclude dust. Laminated seals are used successfully on front wheel hubs, rear axles, rear crankshaft, universal joints and on propeller shafts.

Special properties can be obtained by impregnation. For instance, leakage of pressurized lubricants or entry of water and mud can be prevented by impregnations with paraffin, petrolatum and graphite.

Although many impregnated felt sealing materials are specified individually for particular end use requirements, certain materials have been pretty well standardized. This is especially true of those seals consisting of felt impregnated with natural rubber or a synthetic elastomer. Controlled ratios of felt fiber to impregnant make these materials positive-sealing but self-lubricating, useful for packing washers or heavy-duty bearing seal applications. Impregnants used, in addition to natural rubber, include Hycar, Neoprene and Buna S. The choice, of course, depends on the particular chemical conditions encountered.

For plain or laminated felts, not impregnated, it is possible to outline the selection of felts for various service conditions. When shaft speeds exceed 1000 fpm., dimensionally stable F1, F2 and F3 are recommended for washers used on pumps, shafts and wheel bearings. The first two, characterized by high density, low permeability and maximum cohesive strength are specified for difficult oil or grease retaining conditions. Under less critical conditions, F5 or F6 are most satisfactory, and for shaft speeds below 750 fpm., F10 or F11 can be used. Dust exclusion seals for journal speeds over 1000 fpm., such as those used in automotive wheel bearing assemblies, are made principally from F7, and for lower speeds from F11, F13 and F15. Ball bearing seals require a precision type equivalent to F50.

Wicking

Automatic feeding of oil to a bearing by means of felt rods or pads is known as wicking. However, there are several ways in which this can be done, and the installations can be classified as follows: bottom wick oilers, syphon wick oilers, absorbent or pad feed oilers, and top feed oilers. The syphon and pad feed lubricating systems are most widely used, but bottom wick oilers are generally considered most efficient, as they allow return of unused oil to the reservoir. In top feed oilers, where the wick extends down from the bottom of the reservoir, the wick serves as a partly controlled obstruction. Before installation, all wicks are saturated with oil of the grade to be used as a lubricant.

In every case the wick material must have high absorption capacity and capillarity. Other factors must be considered in selection, however; these are porosity, filter efficiency, density, size, fiber quality and acid neutrality. Careful control of chemical properties is necessary to prevent corrosion of adjacent metal or cracking of lubricants. It is important to have a highly cohesive material constructed from fibers of medium to long length and having low residual ash content to minimize glazing or scoring. This prevents fiber disintegration and subsequent clogging of the lubricating points.

From a design viewpoint, the felt qualities of interest in wicking are three: absorption capacity, wick-rise rate and wicking distance.

As would be expected, the absorption capacity of felt increases in direct inverse proportion to density. Both wick-rise rate and wicking distance increase with density and are inversely proportional to oil viscosity. Wick-rise rate and wicking distance are independent of wick size or cross-sectional area; this makes it possible to design wicks to obtain a predetermined rate of oil delivery. Thus, for a given wicking distance, the delivery rate is the product of wick-rise rate and cross-section area. Bottom wicks, though limited in wicking distance to a maximum of about 6 in., provide the greatest delivery rate within this distance. Charts are available showing the relationships among wicking distance, wick-rise rate and oil viscosity for different felts. Fairly precise formulas are also available for calculating the necessary wick area from a knowledge of lubrication requirements and the density, wick-rise rate and absorption capacity of the felt.

Ideally, selection of the proper wick felt for any individual application is best determined by an actual performance test, but certain generalizations can be made. If the wick is to be used in a bottom or syphon feed system, or if a round drilled

Final finishing operations on this glass are performed on a felt polishing wheel. (Courtesy The Felt Assn.)

wick is needed, a high-density standard wick felt having maximum wick-rise rate and wicking distance is recommended. These requirements are met by F1 or other back check grades. For punched wicks in short lengths, sheet felts of comparable density (16S grades) are sometimes used. If, on the other hand, the felt is to be used as a saturated reservoir within an enclosed bearing or journal box, or as an absorbent pad or strip oiler, a low-density standard wick felt with maximum absorption and storage capacity is recommended. Here, the firm pad and extra firm pad grades, characterized by F10 and F5, are used. For thin reservoir retainers in enclosed bearings which require high dimensional accuracy, ball bearing felts (F50) are sometimes used.

Besides lubrication applications, wicks are also used to feed water, ink and other process fluids in automatic printing equipment, numbering machines and postage meters. Back checks are used for ink rollers in automatic cancelling and recording machines and for pads to deliver solvent to the master roll of duplicating machines, where firmness and dimensional stability are important. A tape-moistening wick, on the other hand, can be relatively soft and a firm pad is used. Wicks can also be impregnated with grease, glycerine, graphite, tallow, hydrogenated and sulfonated oils, silicone greases and wax for self-lubricating parts in mechanical movements.

In certain cases it is not possible to secure the desired wicking characteristics with wool alone. In a gasoline stove, for instance, a cotton-mixed soft white pad is used to siphon feed gasoline from the supply source to the pan from which the burner wick extends. Another use for cotton-wool blends is in stamp pads, which must serve as both reservoir and wick. Materials for such applications have been standardized and are called stamp pad felts.

Filtering

As a medium for mechanical filtration of air, gases and liquids, felt offers controllable permeability and particle retention efficiency. In addition, wool is nonreactive to many chemical agents and felt can be made chemically neutral and sterile. Thus, felt filters can be used in the preparation of industrial chemicals and electroplating solutions, as well as for nutrient broths and fruit syrups.

Long experience in designing filters for specific needs has resulted in a more or less standard line of filter felts, each grade being particularly adapted to a certain type of service. These filter felts range in air permeability from 2 to 280 cu. ft. per min. per sq. ft. surface area based on a 0.5-in. water pressure drop. Some are entirely wool, but others are mixed with cotton, either to obtain certain filtration characteristics or to cut material costs where long use cannot be expected anyway.

Selection of the proper felt for a filter involves a careful balance of two factors—permeability and particle retention efficiency — together with consideration of cost and permanence. Not only must the filter be tight enough to prevent more than a certain maximum amount of impurities from passing through, but it must also be porous enough so that a certain maximum pressure drop is not exceeded. Design tables and charts to help reconcile these conflicting variables are available from felt manufacturers. As for cost, it is clear that a type of service which results in rapid clogging of the filter generally calls for a low-cost and thus expendable filter material.

In a domestic fuel oil burner, it is important that small particles in the oil be prevented from plugging up the burner. The felt used is a firm grey pad which is porous enough to keep the filter from plugging up quickly and, therefore, lasts a long time. Relatively slow flow rates make it possible to achieve high particle retention efficiency despite the porosity. A similar use is the recovery of contaminated crank case oil in airplanes. The somewhat higher flow rates employed make it necessary to use a finer, firmer back check to obtain the desired efficiency.

Where fairly high flow rates are required, as in most process equipment, cotton-mixed felts are generally used. In the filtration of latex in rubber manufacturing, multiple layers of cotton-mixed lining felt are used. This low-cost construction makes it economically feasible to discard the top layer when it becomes plugged. Paints and lacquers used in the automotive industry are recovered by similar filters. More porous materials are used in filter bags which remove impurities from food syrups and plating solutions, and in filtering nitrocellulose for photographic film coatings.

Felts used in filters for air-conditioning units vary according to the particular type of equipment. Throw-away filters incorporate cotton, whereas more permanent filters may use all wool in low to medium densities. Bag-type filters with outer cleansing and blow-back ring permitting escape of air and collection of dust inside the bag are used to filter out dusts from industrial processes. Since this application requires a felt having good strength and minimum stretch, a ball bearing felt is used.

Insulating

Felt, being essentially wool, is an important insulating material. However, even lower thermal co-efficients are offered by another material processed by the felt industry. This material, known commercially as Kapok, is a blend based on a fiber grown on a silk-cotton tree in the tropics. It is lighter in weight and includes a greater volume of dead air than wool felt.

Kapok is not manufactured in thicknesses over ½ in., but layers can be built up to obtain desired thermal coefficients. Thicknesses over 1 in. are proportionally more effective for thermal insulation but, for sound absorption, increases in effectiveness are small and use of thicknesses greater than 1 in. is seldom justified. Charts on Kapok are available which give the thermal coefficients for various thicknesses and the noise reduction coefficients for various frequencies.

Some applications require felts having greater density, strength and wearing quality than Kapok. Standard felts used for this purpose include F-11, F-15, a hair-modified Kapok, F-7 and F-3, in order of increasingly higher thermal coefficients. All except the modified Kapok are much denser than Kapok. Coatings and laminations previously described can be used to meet special service conditions.

The decision between Kapok and wool felt, then, depends on weight and strength considerations as well as insulating efficiency. Where light weight and lowest possible thermal coefficients are desired, as in airplanes and truck bodies, Kapok is used. In weather stripping of doors and windows where compression is involved, soft and firm pad felts are used.

Acknowledgment

The assistance provided by the literature and personnel of the following organizations in the preparation of this article is acknowledged with appreciation:

American Felt Co.
The Felt Assn.
The Felters Co.
Western Felt Works

Mash Resistance Welding Produces Flat Seams in Steel

by O. BRONER, Sciaky Bros., Inc.

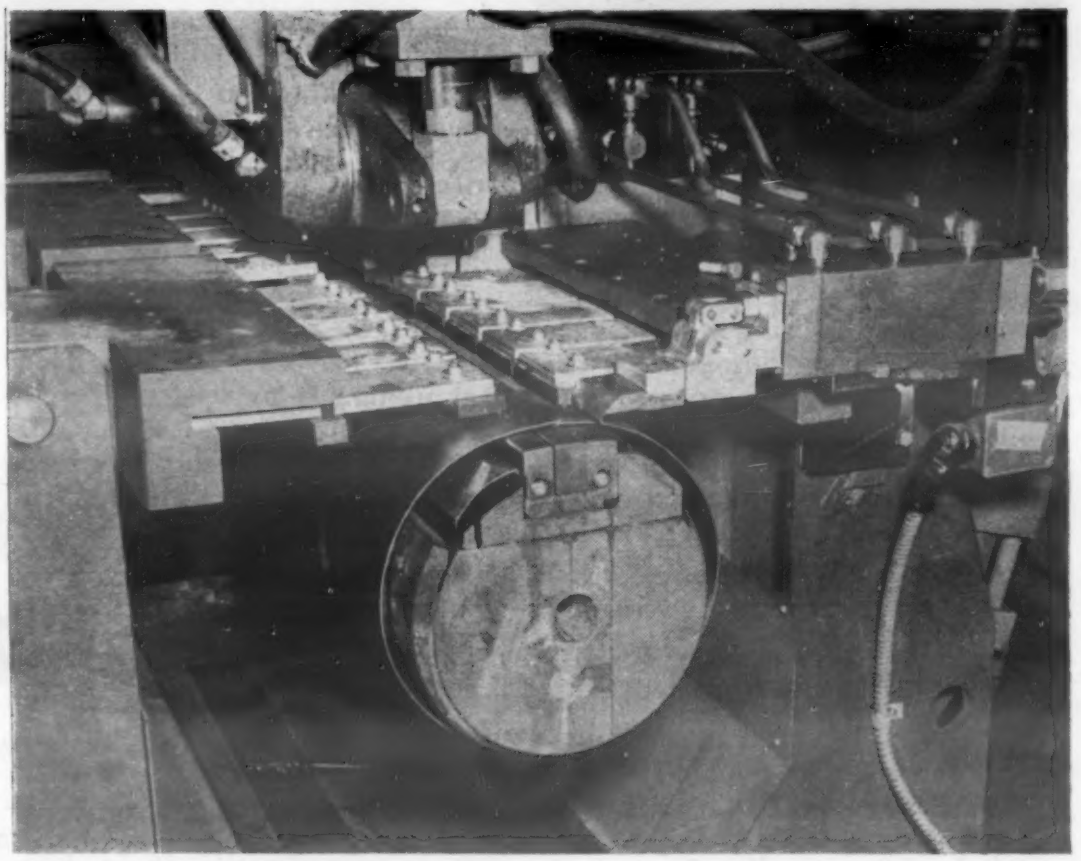
Joints produced by this relatively new technique are suitable for many uses without further grinding or finishing.

• WHEN MILD STEEL SHEETS are to be joined end to end without overlap or other protruding metal, they can be welded by either the fusion or resistance welding processes. The electrical resistance flash-butt welding system is most often used for such applications, but has the disadvantage of leaving a flash that must be removed by grinding or machining. Mash welding is a relatively new application of resistance welding technique. It makes use of either the seam welder or the projection type welder, and may sometimes be a better solution for this problem.

In conventional seam welding, the sheets are ordinarily overlapped ⅜ to 1 in., depending upon the thickness of the sheet stock being welded. Any attempt to reduce this overlap may result in sheet deformation and spitting of the weld metal at the faying surfaces. In mash welding the amount of overlap is limited to approximately 1½ times the sheet thickness, and the welding pressure is increased to approximately twice that required for conventional seam welding, thus forcing the plastic metal from an overlap of two sheets into a single sheet only slightly thickened at the weld joint. Because the weld metal is restrained at both top and bottom by the electrode wheels, there is no ejection of metal and a minimum irregularity in the finished surface at the joint. The joint in the as-welded condition is suitable for many purposes without further grinding or other finishing procedures.

Weldable Steels

Mash welding is, therefore, a resistance welding method that will produce at resistance welding speeds the equivalent of a butt-weld in many types of sheet steel applications without the need for grinding or otherwise machining the weld-joint surface. It is not generally recommended for the joining of gages of steel greater than ⅛ in. in thickness, nor for the welding of scaly or rusty steel unless precleaned, nor for free-machining steels. It is not recommended for the low-alloy high-strength air-hardening steels, unless some provision is made for post-heating. This is especially true of the air-hardening steels when welding is done with a back-up bar or mandrel on the underside of the work, as the back-up bar acts as a chill plate.



Close-up shows cylinder with metal overlap ready for welding. (Courtesy Moloney Electric Co.)

Some stainless steels can be mash welded satisfactorily for many purposes using conventional synchronous control with short weld-on and weld-off timing. It is difficult to obtain consistent overlap edge fusion on some stainless steels, and for that reason it is not generally recommended for stainless steel containers used for food, dairy products, beverages, etc.

The stock ordinarily requires no special preparation for mash welding. When mash welding with a seam welder, a constantly rolling pressure is applied as the current passes through the wheels and the work pieces, but when mash welding with the projection type "C" frame welder, the entire width of the overlap is used for application of current and pressure, the small amount of overlap of the contacting parts serving to concentrate the pressure and current at the point of welding. In general, the seam welder type of mash welding machine is used for joints longer than 6 in.

Overlap of the sheets should be

Vertical weld on shell of this transformer housing is mash-welded.

approximately 1½ times the thickness of the stock being welded, but when welding very thin stock it is necessary to increase the overlap so as to minimize errors caused by gaging and/or variation in shear-line. After welding, the thickness of the welded stock at the weld joint will be 10 to 15% greater than that of the original sheet thickness.

When mash welding with seam welding equipment, the welder may be of the:

1) Wheel to mandrel type, with work clamped to the mandrel.
2) Wheel to wheel, with the work held between the wheels and clamped to a traveling fixture actuated by the friction of the rotating welding wheels.
3) Wheel to fixture, in which the fixture itself serves as the mandrel and the wheel holding pressure head is driven by a motor-driven lead screw, causing the wheel to rotate as it traverses the length of the weld joint.

When mash welding on the projection type "C" frame welders, the work is firmly clamped to the lower die, and the upper die descends to apply heat and pressure, as in conventional projection welding, to weld the complete joint all at one time.

Mash welding can be done on conventional resistance welding equipment as described, but special equipment, designed for specific applications, so as to incorporate the welding, gaging and clamping with an automatic sequence to obtain the best possible results at the highest rate of production, is often used. Most mash welders now in service incorporate these automatic gaging and clamping devices so as to attain the utmost efficiency.

The pressure and secondary current required for a given application will depend upon the type of material to be welded: the thickness, the overlap, and the type of underside support. Because of its inherent design and lack of concentration of heat and pressure, the mandrel type equipment will not be as efficient as the type utilizing electrode wheels for both the upper and lower sides of the weld joint.

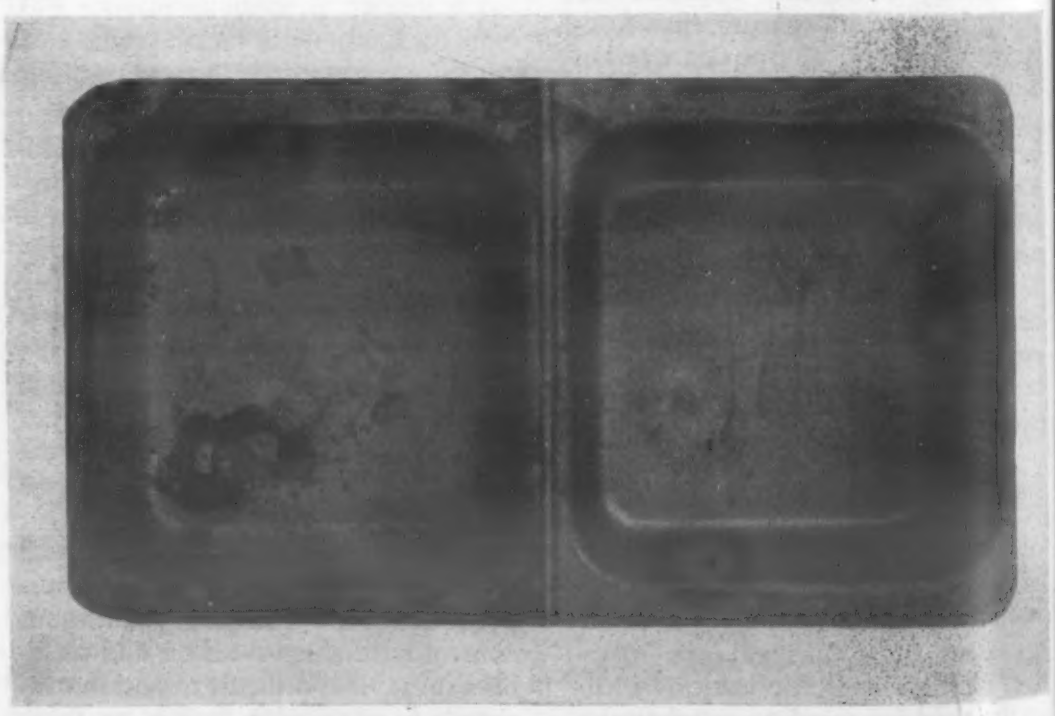
Typical Applications

Mash welding can be used to advantage in many fields of materials processing. The making of cans for electrical transformers illustrates how mash welding can be used to advantage. The steel cylinders having longitudinal joints vary in length from 36 to 60 in., the thickness of stock varying from 0.093 to 0.109 in. These cans are now being welded on a production basis on a special seam welder having a lower mandrel incorporating gaging and clamping devices, and with the travel of the upper electrode wheel actuated by a motor-driven lead screw connected to the welding head assembly.

Other applications for mash seam welders include the joining of two deep-drawn kitchen sink units so as to make a dual sink unit. The metal used in this application consists of mild steel enameling stock, and the joint is approximately 36 in. long. This operation is accomplished on a mash seam welder, especially designed for this particular application, incorporating a special lower arm with clamping and gaging devices, and with travel of the dual weld head assembly actuated by a motor-driven lead-screw attached to a traveling subframe on which is mounted the dual electrode heads and the welding transformer. On this particular machine the series welding principle was employed to simplify the mechanical electrical items of the equipment.

Another problem for which mash welding provided the answer was in the fabrication of warm air registers at the Lima Register Co. Here a projection welder was used to join the four strips of metal forming the rim of the register. The strips were mash welded into a single rectangular frame by joining at each of the four mitered corners, then grinding lightly at the weld line. When painted over, the joints are practically invisible. After the mitered strips are welded into a single piece, a flange is formed around the edges of the frame. The metal is 16-gage mild steel. Production obtained with a single projection welder is 125 frames per hr., or 500 welds at the mitered corners each hour of operation.

Other places where mash welding can be used to advantage are in the joining of old and new coils in continuous lines for tin mills, skelp mills, press operations, roll forming operations, as well as in the joining of narrow sheets of steel when the wider sheets are unavailable or are economically unjustifiable because of premium width costs.



The seam joining the two sections of this duplex sink are mash-welded.

Materials & Methods Manual

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This is another in a series of comprehensive articles on engineering materials and their processing. Each is complete in itself. These special sections provide the reader with useful data on characteristics of materials or fabricated parts and on their processing and application

Heat Resistant Castings—
Their Selection and Application

by H. R. Clauser, Managing Editor, Materials & Methods

Heat resistant castings have many important uses in a number of fields, including the ore reduction, cement mill, ceramic and glass industries, the oil refinery and process industries, and in the steel plant and heat treating equipment fields. Their successful application in these fields depends to a great extent on selection of the proper alloy from among the many that are now available. This manual is intended to serve as an aid to proper selection by giving the engineer and designer a comprehensive picture of the standard types and grades of heat resistant alloys. General composition, high temperature strength properties, corrosion resistance, special service properties, and processing characteristics of the alloys are all covered in detail. In addition, the general types of applications for which each grade alloy is best suited are given.

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Introduction

In the design and production of an increasing number of products, engineers and designers are confronted with the problem of selecting materials to meet high temperature service conditions. There are a bewildering number of possible compositions from which to select, and this frequently complicates the task of selection.

The purpose of this manual is to aid in the selection problem by covering in some detail one broad group of heat resistant materials—namely, the heat resistant casting alloys. The other broad group of heat resistant materials are the wrought alloys, which also have wide application, and in many cases compete with castings. However, due to space limitations they cannot be covered here, but will be taken up at a later date.

The heat resistant casting alloys covered in this manual are those which are normally used either continuously or intermittently at temperatures above 1200 F. They include the straight chromium, iron-chromium-nickel, and nickel-chromium-base alloys. Although chromium-base, cobalt-base and nickel-molybdenum-base alloys also fall within this classification of heat resistant casting alloys, they will not be covered in this manual. Their use is rather limited to special service applications. Cobalt-base alloys are used in jet engines and gas turbines. Nickel-molybdenum-base alloys have found some use for certain heat treating equipment parts.

Heat resistant castings must meet two basic requirements: (1) they must have satisfactory surface stability (corrosion resistance) in the atmosphere and at the operating temperatures to which they are subjected; and (2) they must have the necessary mechanical properties to meet service conditions. At high temperatures there are many more operating variables than at low temperatures and, therefore, selecting a heat resistant alloy that will meet these basic requirements in a particular application is no simple matter—as will be shown in a later section.

The use of heat resistant castings is wide and varied. In the heat treating furnace and equipment field they are used as pots for molten salt and metal baths; as structural parts, such as roller hearths, walking beams and chain conveyors; as containers for carburizing and annealing; and for a multitude of other uses, such as baskets, fixtures, annealing hoods, radiant heater tubes, and thermocouple protection. In the steel industry blast furnace blowpipes, hot-blast valves and rolling mill guides are only a few typical applications. In oil refineries and process industries large amounts of heat resistant castings are used as tube supports, valve bodies and fittings, burner nozzles, and beams and channels.

Heat resistant castings also find extensive use in the glass, ceramic, cement mill, and ore reduction industries for such applications as cooler spouts, outlet grates, kiln feed parts, chain conveyors, rabble holders and blades. Exhaust manifolds, collector rings, valves and choke tubes of heat resistant alloys are commonplace in heavy duty internal combustion engines, while their application to jet engines and gas turbines is just beginning to be explored.

Heat resistant castings are produced by two main methods—static casting and centrifugal casting. The centrifugal process is used extensively for tubular products such as tubes, pipes and cylindrical objects. Melting is done in electric-arc or in induction furnaces. With some exceptions, castings are seldom heat treated by the producer.

Types and Grades of Heat Resistant Castings

Thorough search over many years for good heat resistant casting alloy combinations has narrowed down the field to alloys composed principally of chromium, nickel and iron.

Chromium content runs from around 10 to 30% in heat resistant alloys. It is a useful alloying ingredient because it is not subject to progressive oxidation at normal temperatures and has relatively high resistance to oxidation (scaling) at elevated temperatures. Chromium also resists the action of many other corrosive agents at normal and high temperatures and, if present in sufficient amounts, endows other metals with this property of chemical inertness. However, chromium has one failing. It promotes the formation of ferrite, which is relatively weak at high temperatures as compared to austenite. Also, ferrite when exposed to temperatures of 1100 to 1650 F tends to transform to a chromium-iron intermetallic compound, known as sigma, which is hard and brittle.

Nickel is usually present in cast heat resistant alloys in amounts up to as high as about 70%. It functions principally as a strengthening and toughening agent. It promotes the formation of austenite, which is strong and relatively stable at elevated temperatures. Nickel, in its own right, also has marked resistance to oxidation, although it is not as potent as chromium in this respect. However, nickel has the disadvantage of being highly susceptible to sulfur corrosion. Also, its relatively high cost and scarcity during emergencies limit its use.

While chromium and nickel have far-reaching effects on the properties of heat resistant castings, the minor alloying elements also influence the properties. Carbon content usually ranges between 0.25 and 0.50%. In general, increasing carbon improves high temperature strength, increases hardness and abrasion resistance, and lowers ductility. Higher carbon content also increases fluidity and ease of casting.

Small amounts of molybdenum (up to around 3%) added to some alloys increases strength and corrosion resistance at elevated temperatures. Nitrogen in very small amounts also improves high temperature strength. Manganese and silicon, which are always present in small amounts, tend to lower hot strength.

Classification of Heat Resistant Alloys

All the common heat resistant casting alloys can be grouped according to composition and metallurgical structure into three broad groups as follows: (1) iron-chromium, (2) iron-chromium-nickel, and (3) nickel-chromium-iron. Chiefly in the interests of simplification and standardization the Alloy Casting Institute has established standard designations and chemical composition ranges covering heat resistant casting alloys produced in excess of about 1% of the total high alloy casting output.

Table 1 gives the composition ranges of the various standard designations and indicates to what broad group they belong. The letter "H" in the designation indicates alloys generally used in applications where the metal temperature is in excess of 1200 F. The second letter represents the nominal nickel type, the nickel content increasing from "A" to "X". These standard ACI grade designations will be used throughout this manual.

The composition ranges of the standard designations as now set up are quite broad. Although they are satisfactory for specifying alloy grades for many general service conditions, it should be recognized that these wide ranges permit differences in mechanical or corrosion resistant properties. Thus, for severe service, alloys are customarily produced to more closely controlled ranges.

The American Society for Testing Materials has set up two specifications covering heat resistant casting alloys. Specification A297-49T covers the standard ACI alloys listed in Table 1, for general application. Specification B190-45T specifically covers chromium-nickel-iron alloys of the HH grade.

There are probably at least a hundred commercial heat resistant alloys available

Heat resistant castings are widely used for conveyor parts. Here is a cast link conveyor for carrying material through a continuous annealing furnace. The analysis of the castings is 37 nickel and 17% chromium. (Courtesy Michigan Steel Casting Co.)

today. Each foundry produces its own special line of alloys under their own trade names. But all of the alloys are composed of the three main elements—chromium, nickel and iron—and minor percentages of other elements; and practically all of them fall within one or another of the standard grades.

Iron-Chromium Types

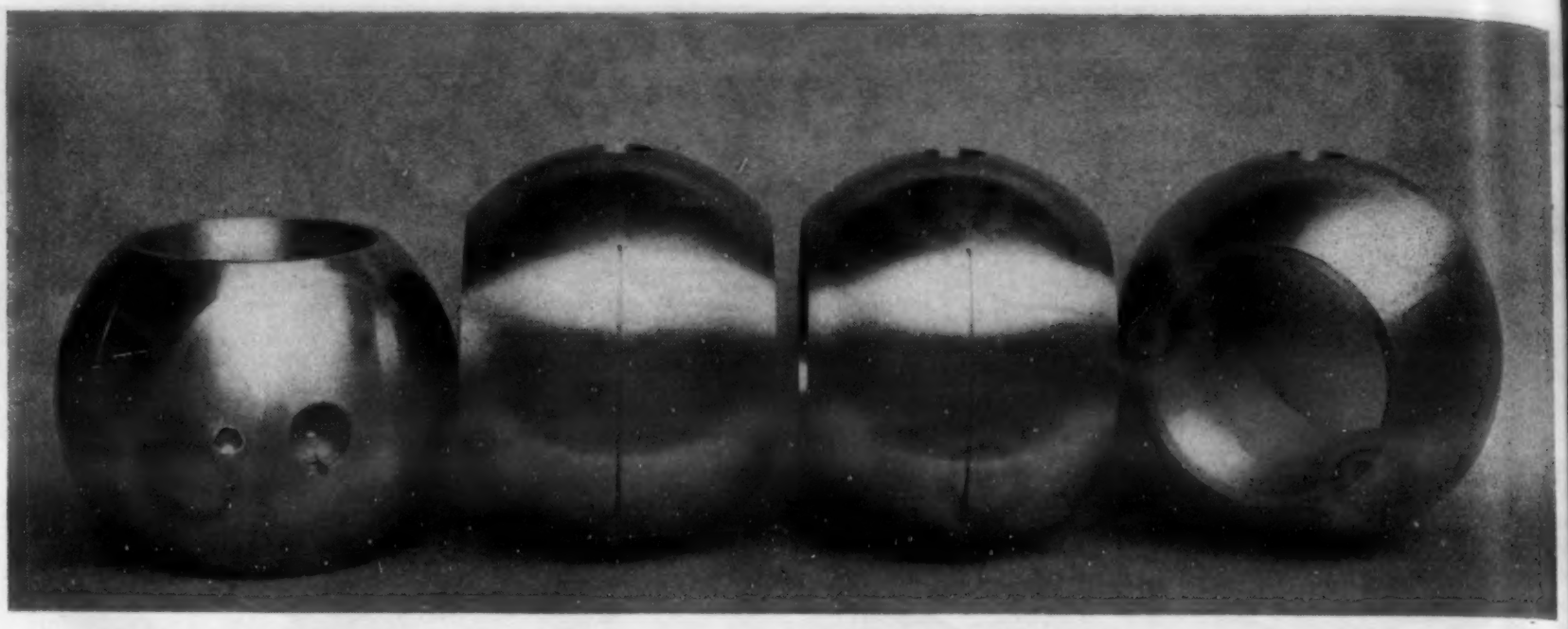
This group of alloys is made up of the chromium predominating types (HB, HC and HD) with up to 30 chromium and up to 7% maximum nickel. The straight chromium alloys are predominantly ferritic and, therefore, have relatively low hot strength. They are seldom used in critical load bearing parts at temperatures above 1200 or 1400 F. They have found considerable use in applications involving uniform heating and severe atmosphere conditions, such as in high sulfur firing.

HC (26-30 Cr, 4% Ni max.) and HD (26-30 Cr, 4-7% Ni) Grades— These two grades are relatively low priced alloys, and are particularly useful where sulfur-bearing atmospheres are involved. Their low creep strength generally limits them in load bearing applications to temperatures up to 1200

Table I—Standard Heat Resistant Casting Alloys

Group	ACI Desig.	Cr	Ni	C	Mn, Max.	Si, Max.	P, Max.	S, Max.	Others
Iron-Chromium (Straight Chromium)	HC	26-30	4.0 max.	0.50 max.	1.00	2.00	0.04	0.04	Mo, 0.5 max.*
	HD	26-30	4.7 max.	0.50 max.	1.50	2.00	0.04	0.04	Mo, 0.5 max.
Iron-Chromium-Nickel	HE	26-30	8-11	0.20-0.50	2.00	2.00	0.04	0.04	Mo, 0.5 max.
	HF	18-23	8-12	0.20-0.40	2.00	2.00	0.04	0.04	Mo, 0.5 max.
	HH	24-28	11-14	0.20-0.50	2.00	2.00	0.04	0.04	Mo, 0.5 max. N, 0.2 max.
	HI	26-30	14-18	0.20-0.50	2.00	2.00	0.04	0.04	Mo, 0.5 max.
	HK	24-28	18-22	0.20-0.60	2.00	3.00	0.04	0.04	Mo, 0.5 max.
	HL	28-32	18-22	0.20-0.60	2.00	3.00	0.04	0.04	Mo, 0.5 max.
Nickel-Chromium	HT	13-17	33-37	0.35-0.75	2.00	2.50	0.04	0.04	Mo, 0.5 max.
	HU	17-21	37-41	0.35-0.75	2.00	2.50	0.04	0.04	Mo, 0.5 max.
	HW	10-14	58-62	0.35-0.75	2.00	2.50	0.04	0.04	Mo, 0.5 max.
	HX	15-19	64-68	0.35-0.75	2.00	2.50	0.04	0.04	Mo, 0.5 max.

**Molybdenum not intentionally added.*



These valve shut-off parts used in hot oil refinery lines are centrifugally cast in a 12% chromium alloy. (Courtesy The Duraloy Co.)

F. However, in non-load bearing parts they perform satisfactorily up to 2100 F. Typical example is the use of HC alloy for burner pipes in the glass industry. The alloys usually contain 0.50% carbon max. for normal service and 3.00% carbon max. for applications in which wear abrasion resistance is a factor.

The higher nickel content of the HD grade results in higher hot strength and better weldability and straightenability than HC grade. Typical applications are roaster furnace rabble arms and blades, salt pots, cement kiln ends and cooler spouts.

HB Grade (18-22 Cr. 2.0% Ni max.)— This grade resists oxidation up to about 1550 F. Its strength at high temperatures is even lower than HC grade and, therefore, finds only limited use in high temperature applications.

Iron-Chromium-Nickel Types

The alloys coming under this classification are partially or completely austenitic. They contain between 18 and 32% chromium, and 8 to 22% nickel, with the chromium content always being greater than the nickel (Grades HE, HF, HH, HI, HK and HL). They are characterized by good high temperature strength, hot and cold ductility, resistance to oxidizing or reducing conditions. They also have good weldability and generally machine satisfactorily. It is important to use these high chromium contents when the atmospheres are high in sulfur, particularly if reducing conditions are encountered.

HH Grade (24-28 Cr, 11-14% Ni)— This grade is one of the two most popular grades of heat resistant alloys, and constitutes about one-third of all heat resistant casting production. This grade is characterized by an unusually wide variation in high temperature properties within the allowable chemical composition range. The composition is therefore critical and must be closely controlled to develop the desired service properties. For practical purposes, the alloys have been divided into two general types to meet different service needs. Type I alloys are partially ferritic and have lower creep strength but higher hot ductility than Type II. Type II alloys are almost, or fully austenitic, and have relatively high creep strength but low ductility compared to Type I.

The two types cannot always be distinguished from each other by mere study of their chemical analysis. They can, of course, be identified by study of the high temperature properties, but determination of these properties is too costly and involved for control purposes. Fortunately it has been found that magnetic permeability can serve as an identification means. ASTM in Specification B190-45T has set up limits of magnetic permeability for each type as follows: Type I—1.70 max.; Type II—1.05 max.

Because of its high creep strength and relatively low ductility, Type II is useful in parts subject to high constant load conditions in the range from 1200 to 1800 F. Some typical uses are for furnace shafts, beams and rollers, and tube supports. Type I alloys are used where hot ductility is more important than high strength. Their use in load bearing applications between 1200 and 1650 F is limited because of the formation of the weak sigma phase in that range.

Both types have good resistance to surface corrosion under the various conditions encountered in industry and are but slightly susceptible to subsurface penetration. HH alloys with carbon up to as high as 2% are suitable for applications involving hot wear.

Experience has indicated that these alloys can withstand reasonably well repeated temperature changes or differentials. However, they are not generally recommended for severe cyclic service such as for quenching fixtures. Also, their weldability and machinability are good and correspond to that of other austenitic alloys.

HI Grade (26-30 Cr, 14-18% Ni)— This grade is quite similar to HH grade. However, with the higher nickel it is less likely to be partially ferritic and possesses more uniform high temperature properties. It has somewhat higher oxidation resistance than HH and can be used up to 2150 F. One typical use of this alloy is in retorts for distillation of magnesium.

HF Grade (18-23 Cr, 8-12% Ni)—This grade is comparable to the popular corrosion resisting 18:8 composition and is suitable for use up to around 1600 F. It parallels HH grade in many uses and combines relatively high hot strength and ductility. Typical uses include burnishing and coating rolls, furnace dampers, annealing furnace parts, and oil still supports.

HE Grade (26-30 Cr, 8-11% Ni)— This grade has excellent high temperature corrosion resistance and is frequently recommended for service in very high sulfur atmospheres where alloys containing high nickel cannot be used. Because of its high chromium content it is suitable for use up to 2000 F. The alloy has moderately high hot strength and excellent ductility. It is widely used for parts subject to high sulfur gases, such as conveyors in furnaces, recuperators, roasting furnace center shafts, and tube support castings. This grade is susceptible to formation of sigma and is not recommended for service between 1200 and 1650 F.

HK Grade (24-28 Cr, 18-22% Ni) and HL Grade (28-32 Cr, 18-22% Ni)— The HK grade seems to be increasing in popularity largely because it provides one of the most economical combinations of strength and surface stability at high temperatures. It has good resistance to industrial atmospheres (except very high sulfur) up to around 2100 F, and is excellent for general structural uses up to the same temperature. In many respects HK grade is similar to HH Type II. The higher nickel content generally assures an austenitic alloy and, therefore, there is little likelihood of developing sigma at service temperatures. However, there are indications that certain unbalanced compositions may cause it to be susceptible to sigma with resulting spread in high temperature properties.

The HL grade is quite similar to HK grade. Typical uses of these alloys are for gas dissociation equipment fixtures, baskets and boxes for malleablizing, calcining tubes,

and enameling furnace fixtures. The higher chromium makes it useful in high sulfur atmospheres where greater strength than available in straight chromium grades is required.

Nickel-Chromium-Iron

These heat resistant alloy types are nickel predominating and are austenitic. They contain from about 10 to 20 chromium and from about 30 to 70% nickel. The composition limits are not as critical as for the iron-chromium-nickel types, and there is no evidence of formation of a brittle phase at service temperatures.

If it were not for their relatively high cost and the problem of corrosion in high sulfur atmospheres, these alloys could be used satisfactorily for practically all applications up to 2100 F. They have good hot strength, carburization resistance, and thermal fatigue resistance. Therefore, they find wide use for load bearing applications and for castings subject to large temperature differentials and cyclic heating. Probably their most serious shortcoming is low resistance to corrosion in high sulfur atmospheres, although they will withstand reducing and oxidizing atmospheres satisfactorily.

There is no sharp line dividing the various applications of the grades making up this group of alloys. The Metals Handbook, however, gives the following general observations:

1. As nickel content increases, the tendency to carburize decreases.
2. As nickel content increases, tensile strength at elevated temperatures decreases somewhat, but alloys are more resistant to thermal shock.
3. As chromium content increases, resistance to corrosion and oxidation increases.
4. As carbon content increases, tensile strength at elevated temperatures increases.
5. As silicon content increases, tensile strength at elevated temperatures decreases, but resistance to carburization increases somewhat.

HT Grade (33-37 Ni, 13-17% Cr)—The alloys in this grade make up about one-third the total annual production of heat resistant castings. They have exceptionally high strength at elevated temperatures up to 1700 F and are resistant to cracking in service involving thermal cycles or large temperature gradients. HT grades can be used satisfactorily up to 2100 F in oxidizing atmospheres and up to 2000 F in reducing atmospheres, but must not be used in atmospheres high in sulfur. Because absorption of carbon up to 0.90% does not cause critical embrittlement, these alloys are widely used for carburizing containers.

Castings of this alloy are widely used for load bearing members in many furnace applications. Other typical uses include retorts, radiant tubes, cyanide, lead and salt pots, and hearth plates.

HU Grade (37-41 Ni, 17-21% Cr)—This grade is similar to HT grade. Its higher chromium content increases its hot strength somewhat. It has an exceptionally high combination of creep strength and ductility up to 1700 F, and replaces HT grade where extra high hot strength is required. Higher alloy content gives it better corrosion resistance than HT grade. Typical uses are salt pots, trays, fixtures, gas dissociation equipment.

HW Grade (58-62 Ni, 10-14% Cr) and HX Grade (64-68 Ni, 15-19% Cr)—These two grades are alloys of the highest nickel content. They are not as strong as the HT grades but are used in oxidizing atmosphere up to 2050 F and in reducing atmospheres up to 1900 F. The higher chromium and nickel content in HX makes it more resistant to corrosion than HW at elevated temperatures. Both grades have high electrical resistivity, which suits them for electrical heating elements. They are used to great advantage where maximum and widely fluctuating temperatures are encountered, because of their ability to withstand cycling without cracking and a minimum of warping. Thus, one of their leading applications is for quenching fixtures. They are also useful in carburizing applications and resist corrosion from tempering and cyaniding salts. Typical applications include carburizing and hardening fixtures, heat treating boxes, retorts and burner parts.

Properties and Selection of Heat Resistant Castings

Selecting the proper heat resistant casting alloy for a given application is far from being a simple matter. There is no all-purpose heat resistant alloy, and, in general, it is impossible to flatly recommend one alloy for any specific application. There are too many variables involved that the final choice is usually a compromise that offers the most or best combination of properties to meet the particular application needs. Therefore, no attempt will be made in this section to recommend any one heat resistant alloy for a specific use. The best we can do is explain the significance of the various selection factors and properties that must be considered and point out what alloy types or grades should be considered for various end-service requirements.

Before making a final choice the advice of reliable producer or producers of heat resistant castings should be sought. Their knowledge and their experience in handling similar problems in the past can often save considerable time and expense. The producer should be given complete information about the requirements of the casting and under what conditions it will operate, so that he can base his recommendation on all the facts.

Following is a list of most, but not necessarily all, of the possible conditions that may have to be considered in the selection of a heat resistant casting for any given application:

1. Temperature of operation.
2. Possible maximum temperature.
3. Temperature cycling.
   a. Range of temperature cycling.
   b. Frequency of temperature cycling.
4. Thermal shock conditions.
5. Type and size of load.
6. Manner of support.
7. Type of atmosphere or other corrosive conditions.
8. Type of liquid bath, if any.
9. Abrasive or wear conditions.
10. Size and shape of part.
11. Continuous or intermittent operation.
12. Expected life.
13. Cost.
14. Ease of replacement.
15. Further processing, such as welding or machining.

The significant properties of the alloys that must be considered in selecting and designing heat resistant castings to meet the above operating conditions are as follows:

1. High temperature strength.
2. Ductility at high and intermediate temperatures.
3. Surface stability (corrosion resistance).
4. Thermal expansion and dimensional stability.
5. Resistance to thermal fatigue.
6. Resistance to carburization and embrittlement caused by it.
7. High temperature wear resistance.
8. Thermal conductivity.
9. Room temperature properties.
10. Processing characteristics — machinability and weldability.
11. Castability (to assure sound castings).

Data available on some of the above properties, in particular the high temperature properties, are not too complete. And where data are available from several sources, they often do not agree. Although comprehensive investigations are underway, there are at present many gaps, and, therefore, evaluation of the alloys based on test property data must be done cautiously. The plain fact is that much as the engineer

would like to avoid empiricism, his choice of alloy and his design must still be based largely on information that is gained by trying the alloys in service. In short, then, the best method of choosing the proper heat resistant casting alloy is to combine a consideration of past performance with available test data.

High Temperature Strength and Ductility

It is a well-known fact that strength and, therefore, load carrying ability of metals decreases as temperature increases, and heat resistant casting alloys are no exception. It is also well-known that strength properties at elevated temperature must be considered differently than at room temperature.

At high temperatures, metals under stress not only behave elastically as they do at room temperature, but also are subject to slow plastic deformation. Therefore, time becomes a critical influencing factor and conventional tensile test values cannot be used. The problem becomes one of determining the load which at a given temperature will not produce more than a certain allowable degree of deformation in a given period of time. Thus, four factors are involved—stress, time, temperature and deformation.

Creep Strength—The matter of evaluating and rating high temperature strength of heat resistant casting alloys is still controversial. But at present, creep test properties are generally considered the most reliable indication of hot strength under relatively constant temperature conditions. Creep data—more specifically, the limiting creep stress (L.C.S.) to produce a selected minimum rate of creep—is frequently the basis for calculating allowable design stresses. On the basis of experience, the minimum creep rate usually selected for comparison and design is 0.0001% per hr. This is often converted to 1% per 10,000 hr. rate. It is important to note that when creep is expressed in the latter way it does not necessarily mean that the limiting creep stress can be sustained for 10,000 hr. without failure.

Fig. 1 compares the creep strength of representative heat resistant casting alloys. From this and the data in Table 2 it can be seen that HT and HU grades have highest creep strengths up to around 1600 F and are generally preferred for high load applications where atmospheric conditions permit their use. However, above 1600 or 1650 F the HK and HL grades are superior in creep strength and surpass HT and HU by an increasing amount as temperature increases. For example, at 2000 F, L.C.S. for HK runs between 750 and 1000 psi. as compared to only 500 psi. for HT. Fully austenitic HH (Type II) also has good creep strength and compares favorably with HT above 1850 F.

Stress-Rupture Data—Stress-rupture data are often a valuable adjunct to creep strength values in the selection of heat resistant castings and in the establishment of allowable design stresses.

The principal object of a stress-rupture test is to determine the time-to-fracture under a constant load at a constant temperature. It therefore gives a rough approximation of the life expectancy of the alloy under relatively constant temperature conditions. The results are also useful in comparing alloys for service in which severities of loading or overloading might produce failure in a relatively short time.

In general, stress-rupture tests rank the alloys in much the same order as the creep

Table 2—Elevated Temperature Properties

	HC	HD	HE	HF	Type I* HH	Type II* HH	HI	HK	HL	HT	HU	HW HX
Short Time Strength Properties:												
Ult. Ten., Psi. at:												
1400 F	10,000	36,000	—	—	—	35,000	—	—	50,000	34,000	40,000	—
1600 F	5,000	23,000	—	—	—	20,000	—	23,000	30,400	19,000	19,000	—
1800 F	2,500	15,000	—	—	—	11,000	—	—	18,700	11,000	12,000	—
Elong., % in 2 In. at:												
1400 F	65	14	—	—	20	12	—	—	—	14	—	—
1600 F	95	18	—	—	30	15	—	15	—	25	16	—
1800 F	110	40	—	—	65	30	—	25	—	28	20	—
Limiting Creep Stress, Psi. (1% Ext. in 10,000 Hr.) at: 1400 F	1,200	3,500	3,500	5,500	5,000	6,000	6,500	6,500	7,000	8,000	8,500	6,000
1600 F	700	1,900	2,000	3,000	3,000	3,500	3,700	4,300	4,300	4,800	5,000	4,000
1800 F	350	1,000	1,200	1,800	1,600	2,000	1,900	2,500	—	2,000	2,000	2,000
Limiting Rupture Stress, Psi. 100 Hr. at:												
1400 F	3,000	10,000	10,000	12,000	13,000	14,000	14,000	14,000	15,000	15,000	15,000	10,000
1600 F	1,500	6,000	5,000	6,000	6,500	7,000	7,000	8,000	9,200	9,000	8,000	6,000
1800 F	800	3,400	2,200	3,800	3,500	4,000	4,000	4,500	5,200	4,500	4,500	3,500
1000 Hr. at:												
1400 F	2,000	—	—	8,000	—	9,000	8,000	9,000	—	10,000	—	7,500
1600 F	1,200	—	—	3,800	—	4,800	4,800	5,000	—	5,500	6,000	4,500
1800 F	600	—	—	—	—	2,500	2,500	3,000	—	2,500	2,900	2,500
Design Stress, Psi. (50% L.C.S.) at:												
1400 F	600	1,700	1,700	2,700	2,500	3,000	3,200	3,200	3,500	4,000	4,200	3,000
1600 F	350	900	1,000	1,500	1,500	1,700	1,800	2,100	2,100	2,400	2,500	2,000
1800 F	175	500	600	—	800	1,000	900	1,200	—	1,000	1,000	1,000
Mean Coeff. of Linear Exp. In/in./ °F x 10^{-6}												
70-1200 F	6.3	7.7	—	10.0	9.5	9.5	10.0	9.5	—	8.9	9.0	8.0
70-1600 F	6.8	8.5	10.5	10.4	10.0	10.0	10.3	9.7	—	9.3	9.3	8.6
70-2000 F	7.7	9.2	—	10.9	10.8	10.8	10.8	10.6	—	9.8	9.8	9.2
Melting Pt. (Approx.), F	2,700	2,700	2,650	2,600	2,500	2,500	2,500	2,500	2,600	2,425	2,425	2,350

NOTE: The values in this table should be considered as approximate and can vary considerably above or below these values, depending on exact composition, heat treatment, method of manufacture, method of test, etc.

**Type I—partially ferritic; Type II—austenitic*

est. The high nickel alloys, HT and HU grades, have the highest limiting rupture tress for temperatures up to around 1600 F. Above this temperature HK and HL approach HT and, depending on exact composition, surpass it above 1800 F.

Stress-rupture data become particularly useful in design when plotted on the same graph with creep data, as in Figs. 3, 4 and 5. For example, in Fig. 3 if the permissible creep rate were 0.0001% per hr., the limiting creep stress at 1600 F would be 3100 psi., which corresponds to a maximum fracture time of 5000 hr. However, such data must be used with caution. Except for overloads that cause fracture in a few hundred hours, the fracture-time curves are extrapolations at the low stresses. Therefore, they must be considered as representing only the maximum life expectancy, and give no assurance that fracture will not occur at shorter times.

Ductility—Accurate comparison of hot ductility of heat resistant casting alloys is difficult since there is no one generally accepted reference test. Total elongation on both creep and stress-rupture tests are often used as criteria. Also, elongation values in short time high temperature tensile tests are commonly used in specifications as an indication of high temperature ductility.

In general, up to 1800 F the HT grades have the highest ductility, followed by fully austenitic HH alloys, and the HK grades. Above 1800 F all the grades have adequate ductility. Because of the formation of the brittle sigma phase between 1200 and 1650 F, HH Type I alloy develops poor ductility, and its use should be avoided at these temperatures if ductility is important. In many applications where castings are handled at normal temperatures, room temperature ductility is often a consideration.

Short Time Tensile Properties—Short time hot tensile tests in which the test specimen is held at the test temperature for 1 hr. and then pulled cannot be relied upon to indicate how heat resistant alloys will behave in service. The values obtained are as much as five or six times the limiting creep stress values and, therefore, greatly over-evaluate load carrying ability over long periods. Nevertheless, short time tensile tests can be helpful in evaluating resistance to momentary overloads and are included in some specifications. In Table 2 are given the short-time ultimate tensile strength and elongation for the standard heat resistant alloys.

Allowable Design Stresses—A frequently used maximum allowable tensile working stress of heat resistant casting alloys for applications up to 1900 F is taken as 50% of the limiting creep stress for a 1% in 10,000 hr. creep rate. This rule only applies where the temperature is constant and where the changes in stress are infrequent and not excessive. The values given in Table 2 are based on 50% of the limiting creep stress. *Where cyclic heating is involved, design stresses must be much lower by a factor of two or three.*

Where service experience is available, however, allowable design stresses are determined on the basis of the experience of both the user and producer. And their decision depends upon the part and the service conditions. In the case of parts that are quite critical to the successful operation of the overall structure, a more conservative value is used. For example, the allowable design stress for chains and trays for heat treating furnaces is only about 25% of the limiting creep stress. In unimportant parts that are easy to replace, the allowable design stress might be higher than 50% of the creep stress.

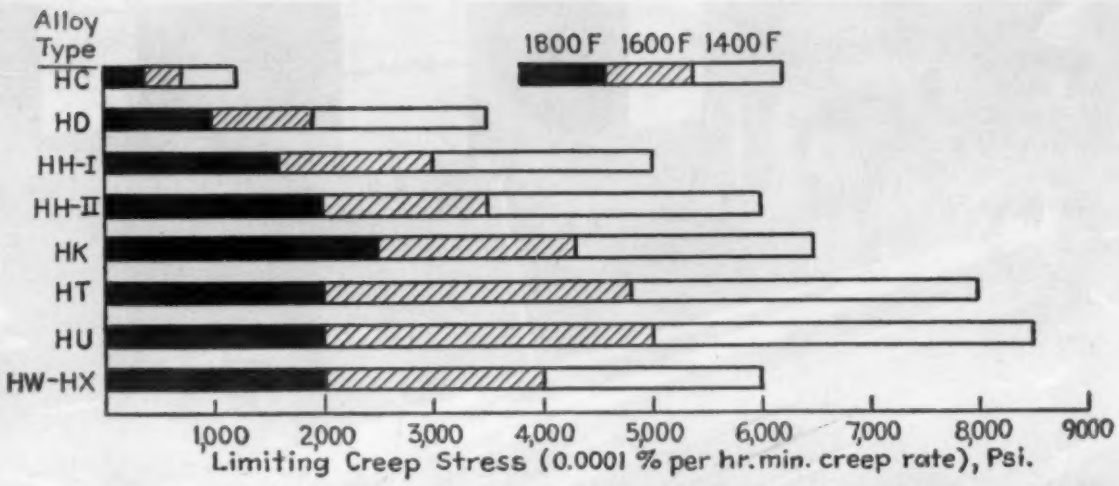


Fig. 1—Limiting creep stress of representative heat resistant casting alloys.

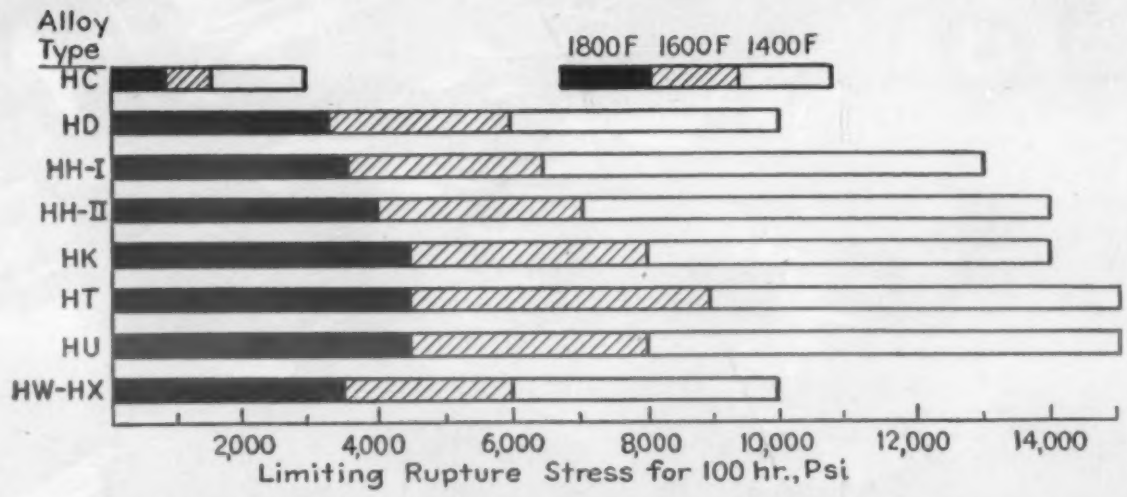


Fig. 2—Limiting rupture stress of representative heat resistant casting alloys.

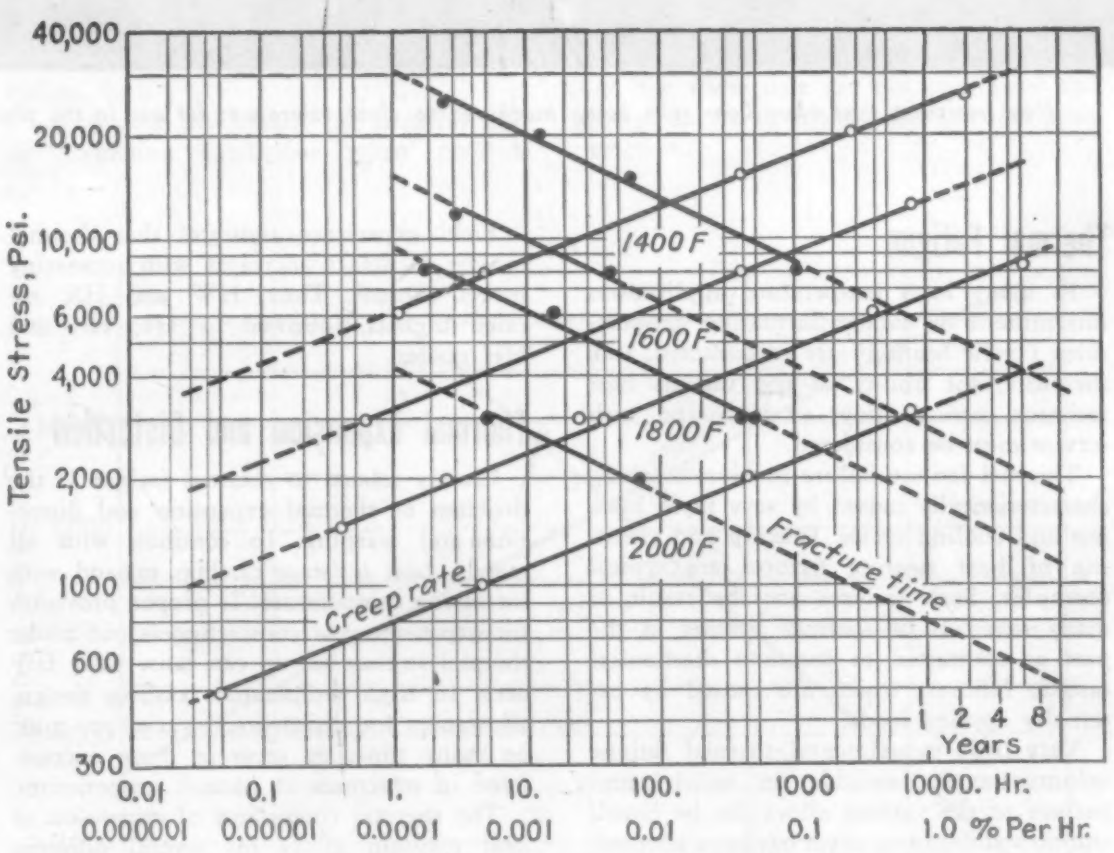


Fig. 3—Creep and rupture properties of an HH alloy containing 25.9 chromium, 11.5 nickel, 0.46% carbon. (Avery, Cook and Fellows)

Heat resistant cast alloy Lehr rolls being machined to close tolerances for use in the plate glass industry. (Courtesy The Duraloy Co.)

Thermal Fatigue

In many high temperature applications intermittent or widely fluctuating temperatures (cyclic heating) are encountered, and, therefore, the ability of the various heat resistant casting alloys to withstand such service must be considered.

Thermal fatigue failure involves cracking characteristically caused by very rapid heating and cooling cycles. Crazing and checking of heat treating fixtures are typical examples. Such failures are the result of many reversals of thermal stresses in the part as contrasted to common mechanical fatigue failures, which are caused by externally applied loads.

Very little experimental thermal fatigue information is available on which comparison of the various alloys can be based, and no standard test as yet has been adopted. However, during the last few years the Alloy Casting Institute has sponsored investigations on thermal fatigue properties and have issued a preliminary report giving some results. While these results do not agree entirely with experience and are by no means conclusive, they do present the beginning of a pattern which should be extended by future investigation.

Field experience indicates that thermal fatigue resistance increases with increasing nickel content. Thus, HW and HX are rated highest, followed by HT, HK and HH grades.

Thermal Expansion and Distortion

Closely related to thermal fatigue is the problem of thermal expansion and distortion and warping. In common with all metals, heat resistant castings expand with increasing temperature. If proper provision for expansion and contraction is not made, thermal stresses set up can cause early failures. In high temperature casting design, allowances for dimensional variations must be many times as great as those encountered in structures at normal temperatures.

The thermal coefficients of expansion of heat resistant alloys for several different temperature ranges are given in Table 2. All the alloys have relatively high coefficients, and the difference between the various grades is small. The high nickel grades as a rule have somewhat lower coefficients than the chromium predominating grades, except the straight chromium types.

In applications where the design of the casting and the nature of the heat source is such that the casting is heated continuously and uniformly throughout, expansion can be provided for relatively easily. However, when the heat distribution throughout the casting is not uniform, distortion or warpage caused by unequal thermal stresses often results. For example, it is practically impossible to heat and cool large castings uniformly; therefore, unequal stresses thus set up within the mass tends to distort or fracture it. Heat resistant alloys inherently have low heat conductivity (about ⅓ that of steel), and this tends to cause greater temperature differences between various regions of a casting.

Unfortunately, these thermal stresses, which are frequently much greater than those from externally applied loads, can seldom be evaluated. But often unfavorable conditions can be overcome by proper design, such as by making castings small and symmetrical, and by allowing maximum freedom of expansion. For example, in the case of hearths for heat treating furnaces, it is better to make them of a number of small elements which are free to expand and contract separately than to use one large plate.

Thus, careful design based on past experience must be largely relied upon to

Table 3—Room Temperature Properties

Property	HC	HE	HF	HH	HI	HK	HL	HT	HU	HW	HX
Tensile Strength, Psi.											
As-Cast	70,000	80,000	80,000	85,000	70,000	72,000	82,000	67,000	67,000	68,000	75,000
Aged	—	—	100,000	90,000	—	78,000	—	75,000	75,000	75,000	82,000
Yield Strength, Psi.											
As-Cast	65,000	45,000	45,000	45,000	45,000	43,000	52,000	37,000	37,000	50,000	45,000
Aged	—	—	50,000	50,000	—	50,000	—	41,000	41,000	—	42,000
Elongation, % in 2 In.											
As-Cast	2	10	35	20	8	17	19	8	8	4	9
Aged	—	—	25	10	—	10	—	4	4	4	9
Red. of Area, %											
As-Cast	—	—	—	30	—	30	—	8	8	—	—
Aged	—	—	—	—	—	10	—	5	5	—	—
Hardness, Bhn.											
As-Cast	180	200	170	180	—	175	192	168	168	179	172
Aged	—	—	190	205	—	205	—	187	187	—	183
Impact, Charpy, Ft.-Lb.											
As-Cast	—	—	—	20	—	—	—	4	4	—	—
Aged	—	—	—	10	—	—	—	5	5	—	—

inimize distortion and warpage. For this eason the heat resistant casting user should onsult with the producer in the early stages f design, so that with their combined ex- erience the best design can be evolved.

orrosion Resistance Properties

In the selection of heat resistant castings, onsideration of surface stability is of para- nount importance. Equipment for high emperature service frequently operates un- er oxidizing or reducing conditions or in ontact with corrosive gases or fused salts. And elevated temperatures generally ac- celerate scaling and the action of corrodents.

No heat resistant casting alloy will meet ll corrosive conditions satisfactorily. For xample, an alloy not good in an oxidizing tmosphere at 1900 F might prove satis- factory at 2100 F under reducing condi- ions. On the other hand, one good at 2100 F in a neutral or slightly oxidizing atmos- phere might flake badly at 1600 F in a educing atmosphere that contained only a oderate percentage of sulfur.

It is therefore dangerous to generalize too ar about corrosion resistance of heat re- istant castings. Very slight changes in alloy ontent or in service conditions can com- pletely change the behavior in what is otherwise an identical situation. The only completely safe procedure is to test the casting alloys under truly representative ervice conditions.

However, past experience allows some eneral observations to be made. Table 4, prepared by ASTM Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys, gives the principal corrosion resistant characteristics of the standard grades.

In general, it can be said that where only air corrosion is involved most of the stand- ard grades will give satisfactory service up o at least 1900 F. Where reducing atmos- pheres are involved, with no sulfur, most f the standard grades are satisfactory up to at least 1700 F. In atmospheres containing sulfur products above 100 grains per 100 cu. ft., the choice becomes limited. The sulfur content of some of the common at- mospheres encountered in industry are as follows:

Unpurified fuel gas when burned—125 grains per 100 cu. ft.

Normally purified coke oven or producer gas—6 grains per 100 cu. ft.

Average fuel oil—60 grains per 100 cu. ft.

Bituminous coal—55 to 300 grains per 100 cu. ft.

Sulfur gases are usually less harmful under oxidizing conditions when present chiefly as SO_2. However, under reducing conditions their corrosive action increases and the choice of alloys becomes narrow. In applications where high sulfur gases under reducing conditions are encountered, only the high chromium grades (HC, HD and HE) are suitable. The high nickel grades are particularly susceptible to corrosion in high sulfur atmospheres, and their use must be avoided in such applications.

A general idea of the resistance to molten salts and metals can be gained by studying Table 4. However, again it must be pointed out that these data are not conclusive and should not serve as the basis for final alloy selection.

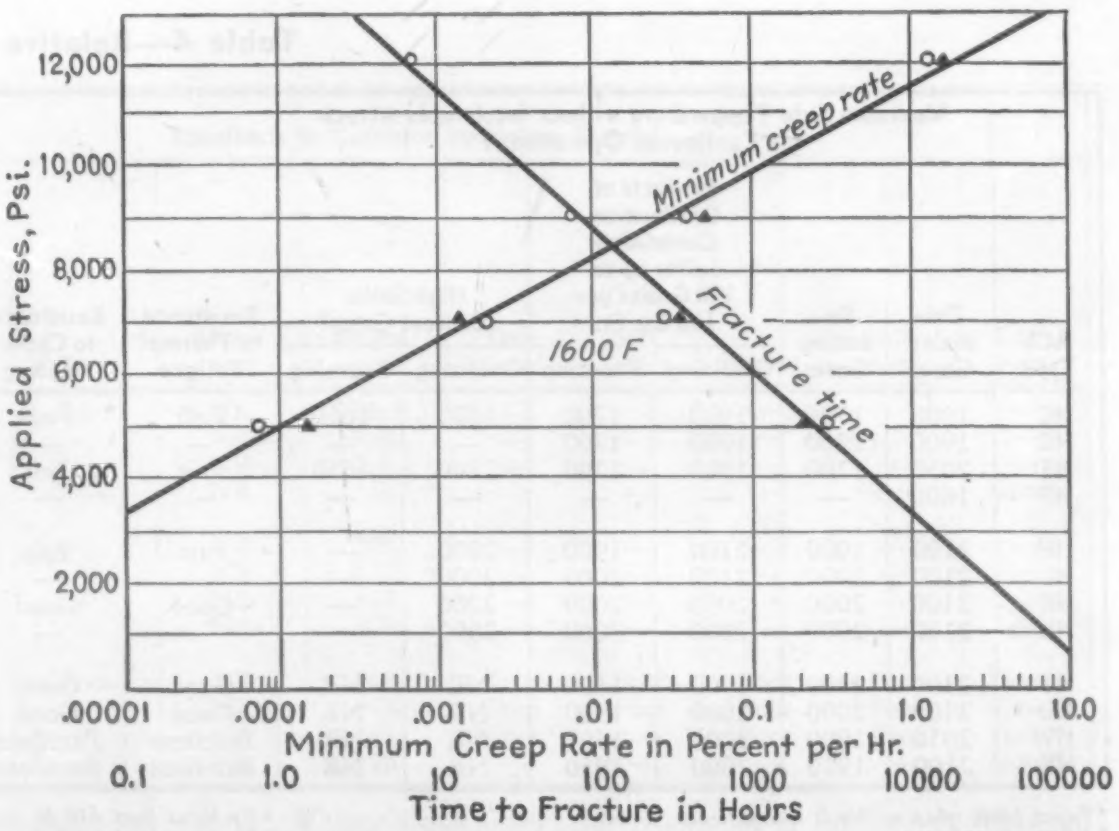


Fig. 4—Creep and rupture properties of HT type alloys at 1600 F. (Alloy Casting Institute)

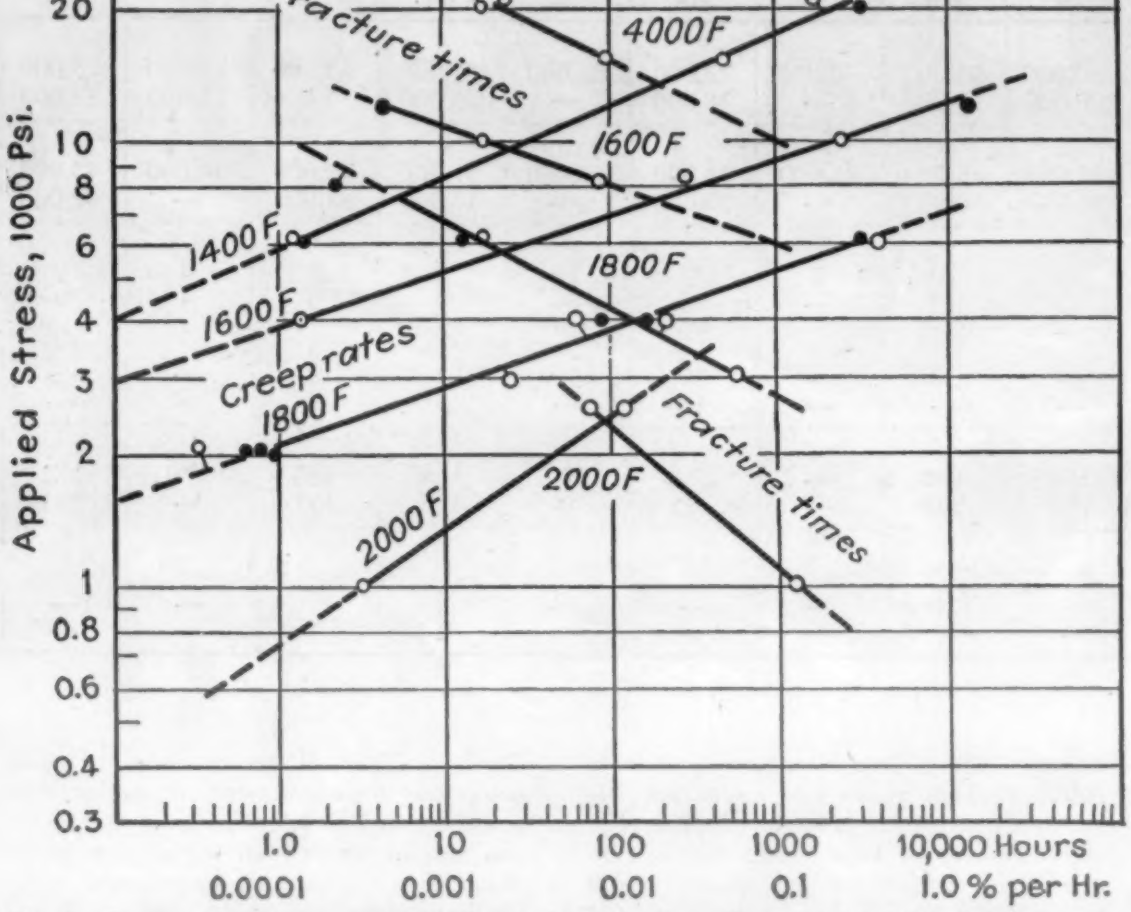


Fig. 5—Creep and rupture properties of a typical HK type alloy containing 26 chromium and 20% nickel. (Avery & Wilks)

Carburization Resistance

All heat resistant casting alloys pick up carbon to a certain extent when subjected to carbon bearing atmospheres at high temperatures. For example, it is possible for some alloys to go from 0.30 to 2% carbon content within a period of several months when used in a carburizing application. A large amount of carburization leads to volume changes, which can cause warpage and distortion.

The chromium predominating grades are generally not suitable for carburizing service except in cases where other requirements dictate their selection. In such cases silicon content should be closely controlled and kept on the high side. Carburization resistance of HH grade is improved with silicon contents of above 1.6%; with HT grade improvement is gained with silicon above 1.3%.

Resistance to carbon penetration increases as nickel content increases. Therefore, the high nickel grades (HT, HU, HW and HX) are all good in this respect. HW and HX grades, being highest in nickel, are rated as excellent.

Room Temperature Properties

Table 3 gives the conventional room temperature properties of the various heat resistant alloy grades. Although room temperature mechanical properties are sometimes used for acceptance purposes, there is little relation between them and high temperature behavior.

Room temperature properties may be of interest in cases where the casting is subjected to severe service stresses at or near normal temperatures. They also are sometimes used as a control test to check on the uniformity of properties or to detect defective material or to give information on fabricating properties.

Abrasion Resistance

In many heat resistant applications, wear due to abrasion is an important consideration. High chromium-high carbon alloys have good abrasion resistance. Of the standard grades, HC with 3.00% carbon max. is frequently used for abrasion resistant service. An advantage of this grade is that it can be machined in the annealed condition and then hardened to as high as 600 Bhn. Other grades often used for abrasion resistant service include HD and HH.

Table 4—Relative Corrosion Resistant Characteristics

ACI Type	Maximum Safe Temperature without Intolerable Attack for Continuous Operation, F[a]						Resistance to Thermal Fatigue	Resistance to Cyclic Heating	Resistance to Corrosion by Salts[b]			
	Oxidizing Gases	Reducing Gases	Products of Combustion Containing Sulfur up to 100 Grains per 100 Cu. Ft.		High Sulfur Content Gases[b]				Drawing and Tempering	Neutral	Cyaniding	High-Speed Salts
			Oxidizing	Reducing	Oxidizing	Reducing						
HC	1900	1700	1900	1700	1800	1650	Poor	Poor	—	Poor	—	—
HD	1900	1700	1900	1700	—	—	—	—	—	—	—	—
HE	2050	1700	1900	1700	1800	1650	Fair	Fair	—	—	—	—
HF	1600	—	—	—	—	—	—	—	—	—	—	—
HH	2100	1900	2100	1900	2000	—	Fair	Fair	Fair	Fair	Fair	Fair
HI	2100	1900	2100	2000	2000	—	—	—	—	—	—	—
HK	2100	2000	2000	2000	2000	—	Good	Good	Good	Good	Good	Good
HL	2100	2000	2000	2000	2000	—	—	—	—	—	—	—
HT	2100	2000	1900	1600	NR	NR	Good	Good	Good	Poor[c]	Good	Fair
HU	2100	2000	2000	1900	NR	NR	Good	Good	Good	Poor[c]	Good	NR
HW	2050	1900	2000	1600	NR	NR	Excellent	Excellent	Excellent	Poor[c]	Excellent	NR
HX	2100	1950	2000	1950	NR	NR	Excellent	Excellent	Excellent	Poor[c]	Excellent	NR

[a] *Values lower when service is intermittent.*
[b] *NR = not resistant.*
[c] *Will give satisfactory service with proper salt control.*
[d] *Resistance is improved when silicon content is 1.5 to 1.7%.*
[e] *Up to at least 650 F.*
[f] *Up to at least 1300 F.*
[g] *Up to at least 775 F.*

Electrical Properties

Compared with pure metals, heat resistant casting alloys have high electrical resistance, and have found considerable application for electrical heating elements in heavy duty service structures, such as furnaces. Cast resistors provide superior strength and resistance to oxidation. They have the further advantages of being rigid and easily mounted.

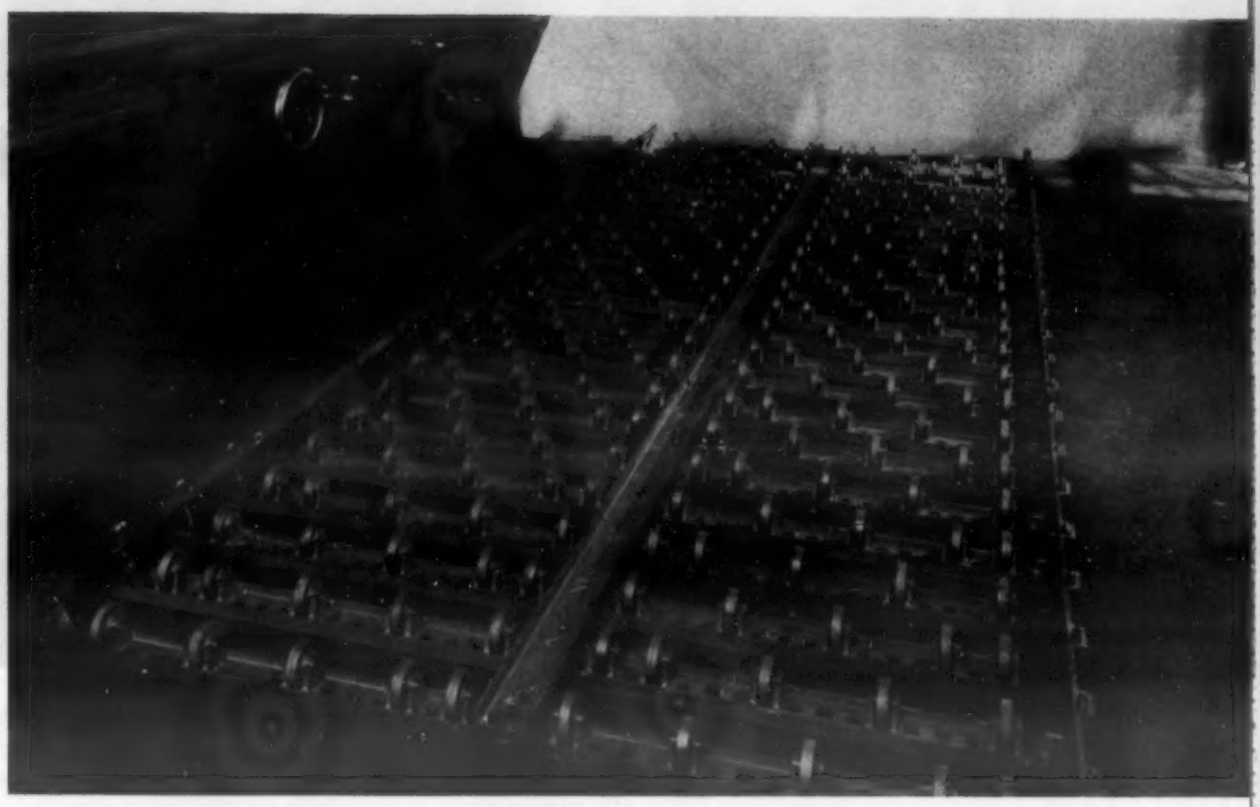
Cast resistor elements are usually of ribbed T or U section and can be made in units having as high as 15 or 20 ft. of heating element. Alloy grades HT (38 nickel, 18% chromium) and HX (65 nickel, 18% chromium) are widely used in these applications and can be used at temperatures up to 1850 and 2100 F, respectively. Grades HU and HW are also used for cast resistor elements.

Welding and Machining Characteristics

All heat resistant alloy grades can be welded by conventional methods where weld metal of equivalent properties is used. These castings can, therefore, be used in fabricated assemblies joined by welding. Repair welding can also be successfully accomplished in all the grades. The high nickel grades as a group are easiest to weld. The austenitic chromium predominating grades are also relatively easily welded, but difficulties are sometimes encountered with the ferritic grades HC and HD. They are preheated at 600 to 1000 F before welding.

All grades are also readily machinable, with the nickel predominating grades again rated highest in this respect. Tapping operations are sometimes difficult without heat treatment on HF and austenitic HH grades, but otherwise the chromium predominating grades machine satisfactorily. Reasonable speeds and heavy feeds are possible using high-speed or carbide tools.

In general, finishing other than machining for fitted parts is not required in heat resistant applications. Pickling practices usually employ nitric acid with small additions of hydrofluoric acid.



This roller hearth is used for annealing sheet brass. The rollers, roller frames and side guards are 37 nickel-17% chromium castings. (Courtesy Michigan Steel Casting Co.)

Soundness and Uniformity of Properties

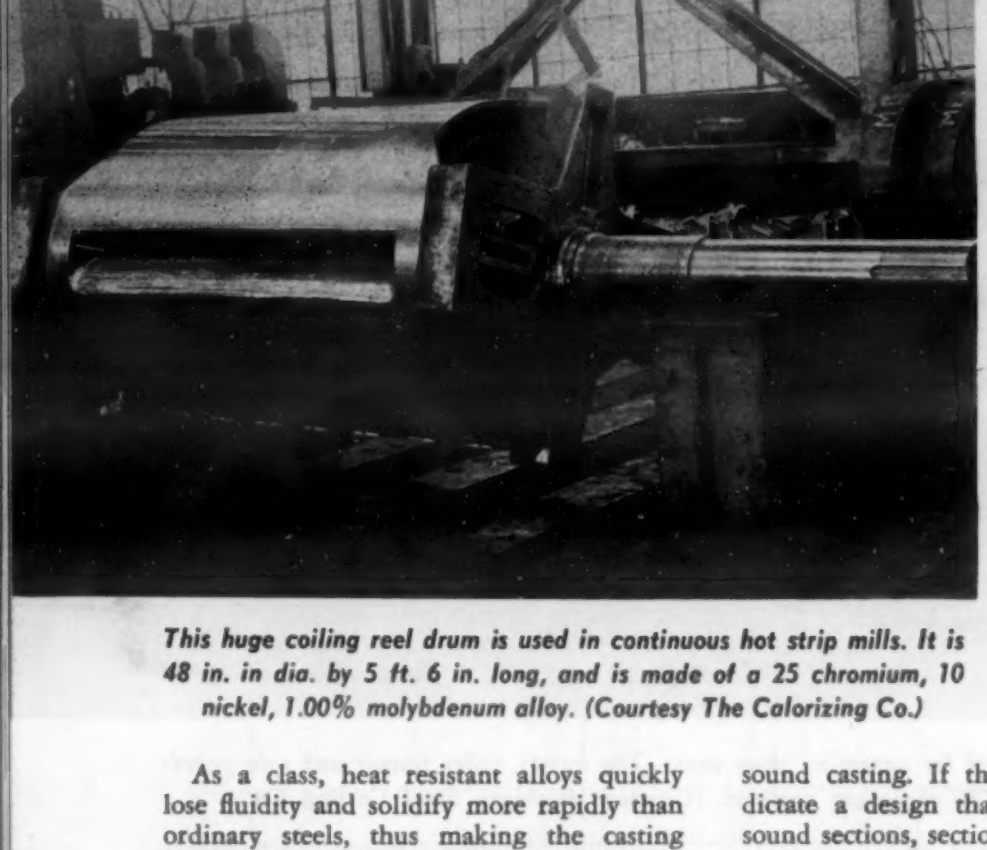
Most of the preceding discussion has dealt with the selection of the proper alloy to meet service conditions, but final selection should also always take into account castability and other factors which influence the production of a sound casting.

Most users and producers of heat resistant castings will agree that soundness and uniformity of properties from one casting to another are extremely important factors in determining a casting's success or failure in service. The best alloy selection can be undone by an unsound casting, or by lack of uniformity in castings of the same design. Unsoundness can have serious effects, not only because of the decrease in effective section thickness, but also because it presents opportunities for possible stress concentrations.

of Cast Heat Resistant Alloys

Resistance to Damage by Carbon Penetration	Ability to Avoid Catalyzing Hydrocarbon Cracking	Resistance to Corrosion by Molten Metals[b]									
		Lead	Tin	Zinc	Aluminum	Magnesium	Type Metal	Soft Solder	Babbitt	Antimony	Cadmium
Poor	Good	—	—	Poor	NR	Good	—	—	—	—	—
—	—	—	—	—	NR	Poor	—	—	—	—	—
Fair	Fair	—	—	—	NR	NR	—	—	—	—	—
—	—	—	Good[e]	Poor	NR	NR	—	—	—	Good[f]	Good[g]
Fair[d]	—	Good	—	—	NR	NR	—	—	—	—	—
—	—	—	—	—	NR	NR	—	—	—	—	—
Good	Fair	—	—	—	NR	NR	—	—	—	—	—
—	—	—	—	—	NR	NR	—	—	—	—	—
Good	—	Good	Good[e]	Poor	NR	NR	Poor	Poor	Poor	Poor	Good[g]
Good	—	Good	Good[e]	—	NR	NR	Poor	Poor	Poor	Poor	Good[g]
Excellent	—	Excellent	Good[e]	—	NR	NR	Poor	Poor	Poor	Poor	Good[g]
Excellent	—	Excellent	Good[e]	—	NR	NR	—	—	—	—	Good[g]

From "Data on Corrosion and Heat Resistant Steels and Alloys—Wrought and Cast," American Society for Testing Materials



This huge coiling reel drum is used in continuous hot strip mills. It is 48 in. in dia. by 5 ft. 6 in. long, and is made of a 25 chromium, 10 nickel, 1.00% molybdenum alloy. (Courtesy The Calorizing Co.)

Jet engine rings cast centrifugally for Pratt & Whitney and Westinghouse Electric. (Courtesy Cooper Alloy Foundry Co.)

As a class, heat resistant alloys quickly lose fluidity and solidify more rapidly than ordinary steels, thus making the casting more susceptible to shrinkage, tears, cold shuts and laps.

As a general rule, the nickel predominating grades have best castability. The chromium predominating grades are more difficult to cast, and require slightly greater minimum metal sections. In all grades higher carbon and silicon contents improve fluidity and ease of casting.

The design engineer can often help minimize unsoundness by adapting the design of the casting as much as possible for good foundry practice. To do this, cooperation between user and producer is essential early in the design stages and preferably before the pattern design is begun. The producer should be informed of the exact type of service which the casting will meet. He can often suggest minor changes in design which will help in the production of a sound casting. If the service requirements dictate a design that might result in unsound sections, section thicknesses can often be increased or apportioned slightly differently in order to correct the condition.

Finally, it should be emphasized again that there is no substitute for a good casting. And the best assurance a user can have of obtaining a well-designed, sound casting is to buy his castings from a dependable source.

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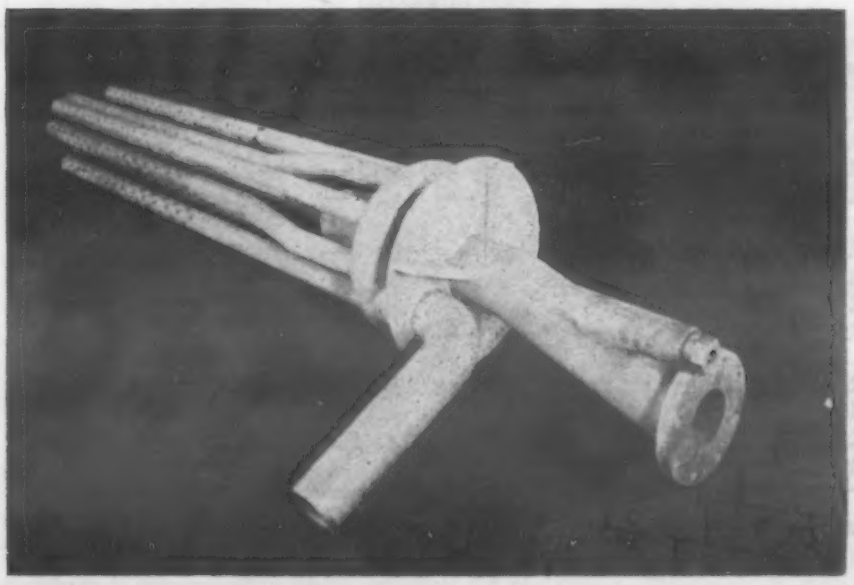
Industrial Heating Equipment Co.
International Nickel Co., Inc., The
Lebanon Steel Foundry
Michiana Products Corp.
Michigan Steel Castings Co.
Ohio Steel Foundry Co., The

A retort and insert assembly for coal distillation pilot plant. (Courtesy Electro-Alloys Div., American Brake Shoe Co.)



Screws and troughs shown in this assembly are of 35 nickel and 15 chromium and are used to convey bar stock through various types of heat treating furnaces. (Courtesy Electro-Alloys Div., American Brake Shoe Co.)

Materials Engineering File Facts

NUMBER 199
October, 1950

MATERIALS DATA SHEET

Cast Zinc Alloys

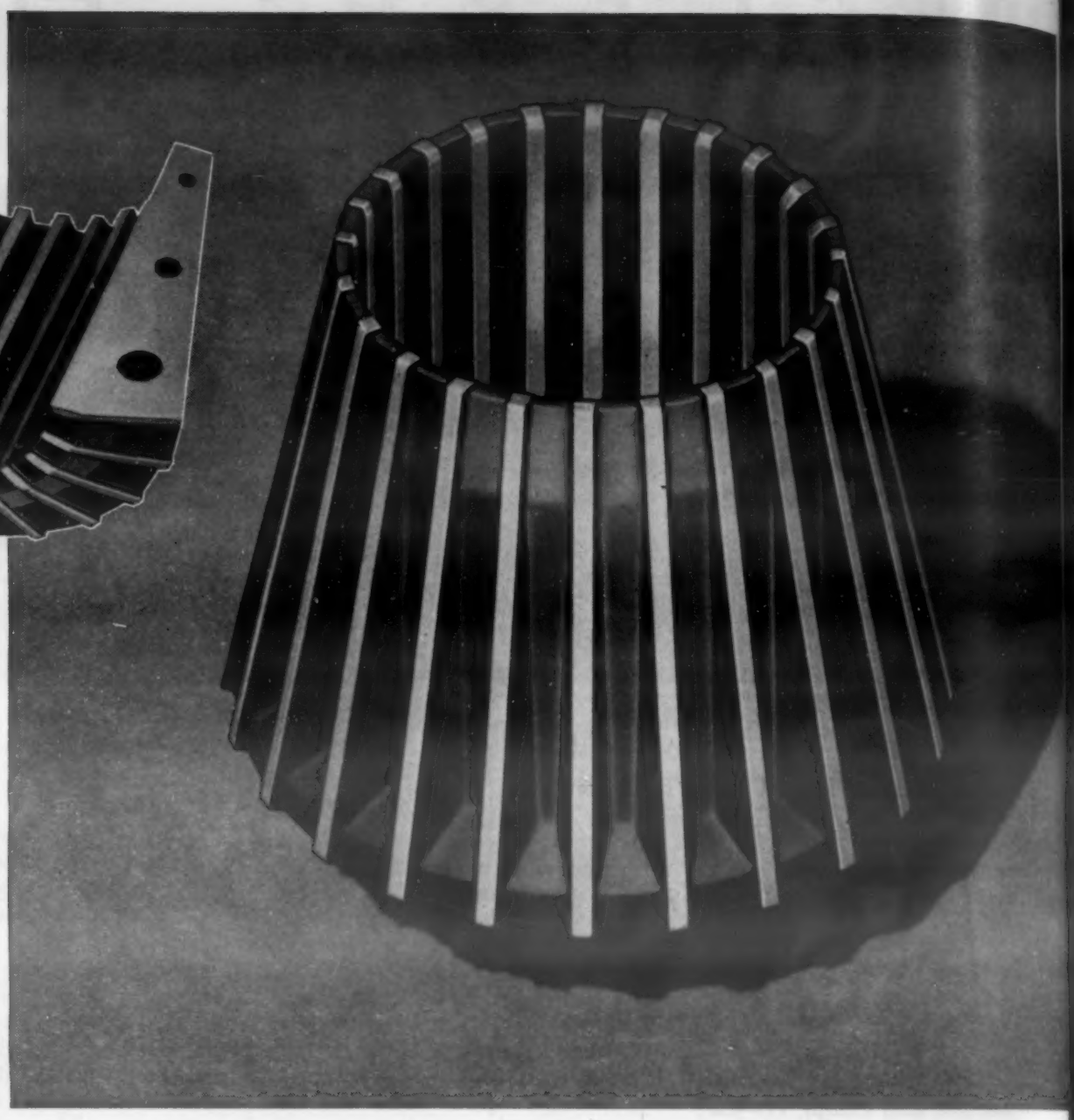
Typical Properties

Type	Alloy XXIII[1]	Alloy XXV[1]	Zinc-Base Slush-Casting Alloy[3]	Zinc-Base Slush-Casting Alloy (Unbreakable Metal)[3]
COMPOSITION, %	Al, 3.5-4.3 Mg, 0.03-0.08 Zn, remainder	Al, 3.5-4.3 Cu, 0.75-1.25 Mg, 0.03-0.08 Zn, remainder	Al, 4.5-5.0 Cu, 0.2-0.3 Zn, remainder	Al, 5.25-5.75 Zn, remainder
PHYSICAL PROPERTIES				
Density, Lb./Cu. In.	0.24	0.24	—	—
Melting Point, F	727.9	727.0	734.0	743.0
Thermal Cond., Btu./Hr./Sq. Ft./Ft./F (158-284 F)	65.3	62.9	—	—
Coeff. of Exp. per F (68-212 F)	15.2×10^{-6}	15.2×10^{-6}	—	—
Spec. Ht., Btu./Lb./F (68-212 F)	0.10	0.10	—	—
Elect. Res., Microhm-Cm. @ 68 F	6.37	6.54	—	—
Solidification Shrinkage, %	1.17	1.17	—	—
MECHANICAL PROPERTIES				
Tensile Str., 1000 Psi.:				
Die Cast	41.0	47.6	—	—
Chill Cast	—	—	28.0	25.0
Elongation in 2 In., %:				
Die Cast	10.0	7.0	—	—
Chill Cast	—	—	—	1.0
Hardness, Bhn.: Die Cast	82	91	—	—
Impact Str., Izod Charpy, Ft.—Lb.:				
Die Cast	43.0	48.0	—	—
Chill Cast	—	—	3.0	1.0
Fatigue Str., (End. Limit, 10^8 cycles), 1000 Psi.: Die Cast	6.875	8.175	—	—
Compressive Yield Str., 1000 Psi.: Die Cast	60.0	87.0	—	—
Shear Str., 1000 Psi.: Die Cast	31.0	38.0	—	—
FABRICATING PROPERTIES				
Melting Range, F:	727.9-932.0	727.0-932.0	—	—
Die Casting Temp., Range, F:	740-800	740-800	—	—
Machinability:	Generally, these alloys have good machining characteristics.			
Joining Characteristics:				
Torch Welding	Poor to fair	Poor to fair	—	—
Single Impulse Res. Welding	Poor	Poor	—	—
Multiple Impulse Res. Welding	Fair to good	Fair to good	—	—
Soldering	Poor[4]	Poor[4]	—	—
Standard Finishes:	Mechanical, electrodeposited, chemical and organic			
Common Fabrication Processes:	Welding, soldering, machining Riveting, spinning, cold swaging			
CORROSION RESISTANCE	Excellent resistance to both metropolitan and rural atmospheric corrosion; to hot soapy water, printing ink, trichlorethylene, carbon tetrachloride, dry illuminating gas and moistureless, acid-free hydrocarbons. Fair resistance to pure ethyl and methyl alcohols, glycerine, water, petroleum products. Poor resistance to steam, spray insecticides, animal oils, strong acids and bases, and mixtures of glycerine or alcohol and water.			
	Penetration in in. per year in Palmerton, Pa. and New York City, respectively.			
	0.000078, 0.00022	0.000063, 0.00028		
TYPICAL USES	Automotive parts, household utensils, office equipment, building hardware, padlocks, toys and novelties.	Drop hammer dies for sand castings.	For all slush and permanent mold castings, principally in the manufacture of lighting fixtures.	

[1] *These alloys conform to A.S.T.M. designation B86-49.*
[2] *Mechanical properties of die cast alloys are based on a ¼-in. section; those of chill cast on a ½-in. section.*
[3] *Because of their limited use, little data are available on these alloys.*
[4] *Cadmium-zinc and lead-tin solders diffuse into the casting, promoting subsurface attack. Castings must be nickel-plated to be joined by lead-tin solders.*

Prepared with the assistance of The New Jersey Zinc Co.

Rubber-Flex collet made by The Jacobs Manufacturing Co., Hartford, Conn.



Does the work of 8 collets ...with HYCAR'S help!

MEN who know lathes say the new Jacobs Spindle Nose Lathe Collet Chuck is a world-beater. And one of the important reasons for its success is the Rubber-Flex collet—in which Hycar American rubber is a vital part.

This collet, pictured above, is made of hardened steel jaws bonded and mechanically locked together with Hycar. Each collet has a full ⅛" gripping capacity—making it possible for one Rubber-Flex collet to cover the range of eight split steel collets!

Here's why Hycar is fundamental in the chuck design: the rubber in the collet has to have excellent resistance to heat and to the deteriorating effects of coolants and cutting compounds. On both counts, Hycar fills the bill perfectly.

Another important point: Hycar's resistance to compression set makes it possible for the molded rubber to take *all* of the flexing action. Under tests—over four million individual openings and closings—there was n breakdown in the Hycar rubber separation from the steel collet jaw You can see what that means in lon collet life under heavy duty use.

Use of Hycar in this unusual coll is another in a long series of produ successes. For versatile Hycar is us as a base material . . . as a plasticize for polyvinyl resins . . . as a modifi for phenolic resins . . . as an adhesi base . . . as a latex for coating or i pregnating. Find out how Hycar m help you develop or improve pro ucts, profitably. Just write Dept. HO B. F. Goodrich Chemical Compan Rose Building, Cleveland 15, Ohi

Hycar
Reg. U.S. Pat. Off.
American Rubber

B. F. Goodrich Chemical Company

A DIVISION OF THE B. F. GOODRICH COMPA

GEON polyvinyl materials • HYCAR American rubber • GOOD-RITE chemicals and plasticizers

Materials Engineering File Facts

NUMBER 200
October, 1950

MATERIALS DATA SHEET

Wrought Zinc Alloys

Typical Properties

Type	Commercial Rolled Zinc (Deep-Drawing Zinc)	Commercial Rolled Zinc	Commercial Rolled Zinc	Copper Hardened Rolled Zinc Alloy	Rolled Zinc Alloy
COMPOSITION, %	Pb, 0.10 max. Zn, remainder	Pb, 0.05-0.10 Cd, 0.05-0.08 Zn, remainder	Pb, 0.25-0.50 Cd, 0.25-0.45 Zn, remainder	Cu, 0.85-1.25 Zn, remainder	Cu, 0.85-1.25 Mg, 0.006-0.016 Zn, remainder
PHYSICAL PROPERTIES					
Density, Lb./Cu. In.	0.258	0.258	0.258	0.259	0.259
Melting Point, F	786	786	786	792	792
Thermal Cond. Btu./Hr./Sq. Ft./Ft./F, @ 64 F	62.2	62.2	—	—	60.5
Coeff. of Exp. per F:					
With Grain	18.1×10^{-6}	18.1×10^{-6}	18.8×10^{-6}	—	19.3×10^{-6}
Across Grain	12.8×10^{-6}	12.8×10^{-6}	13.0×10^{-6}	—	11.7×10^{-6}
Spec. Ht., Btu./Lb./F (68-212 F)	0.094	0.094	0.094	0.0957	0.0957
Elect. Res., Microhm-Cm. @ 68 F:					
Hot Rolled	6.06	—	—	6.22	6.31
Cold Rolled	6.10	—	—	—	—
MECHANICAL PROPERTIES					
Tensile Str., 1000 Psi.:[1]					
Hot Rolled	19.5, 23.0	21.0, 25.0	23.0, 29.0	24.0, 32.0	28.0, 36.0
Cold Rolled	21.0, 27.0	22.0, 29.0	25.0, 31.0	32.0, 40.0	37.0, 48.0
Elongation in 2 In., %:[1]					
Hot Rolled	65, 50	52, 30	50, 32	20, 15	20, 10
Cold Rolled	50, 40	40, 30	45, 28	5, 3	20, 2
Hardness, Bhn.:					
Hot Rolled	38	43	47	52	61
Cold Rolled	—	—	—	60	80
Fatigue Str. (End. Limit), 1000 Psi.:					
Hot Rolled	2.5	3.8	4.1	6.1	6.8
FABRICATING PROPERTIES					
Hot Working Temp. Range, F	248-527	248-527	248-437	447-572	447-572
Melting Range, F	887-977	887-977	887-977	887-977	887-977
Ingot Casting Range, F	815-905	815-905	815-905	815-905	815-905
Annealing Temp., F	—	—	221	347	347
Machinability:	Generally, these alloys have good machining characteristics.				
Joining Characteristics:					
Torch Welding	Poor to fair	Poor to fair	Poor to fair	Poor to fair	Poor to fair
Single Impulse Res. Welding	Poor	Poor	Poor	Poor	Poor
Multiple Impulse Res. Welding	Fair to good	Fair to good	Fair to good	Fair to good	Fair to good
Soldering	Good	Good	Good	Good	Good
Common Fabrication Processes:	Drawing, bending, roll forming.				
	Spinning, swaging, impact extrusion.		Swaging, impact extrusion	Spinning, swaging	—
CORROSION RESISTANCE	Excellent resistance to both metropolitan and rural atmospheric corrosion (penetration in in. per year is 0.000064 in Palmerton, Pa. and 0.00028 in New York City); to hot soapy water, printing ink, trichlorethylene, carbon tetrachloride, dry illuminating gas and moistureless, acid-free hydrocarbons. Fair resistance to pure ethyl and methyl alcohols, glycerine, water, petroleum products. Poor resistance to steam, spray insecticides, animal oils, strong acids and bases, and mixtures of glycerine or alcohol and water.				
COMMONLY AVAILABLE FORMS	Rolled strip and sheet, extruded rod and shapes, drawn rod and wire.				
TYPICAL USES	Drawn battery cans, eyelets, grommets, laundry tags, address plates, flashing.		Plates and strip for soldered battery cans, photoengravers and lithographers sheet.	Weather strip, name plates, ferrules, and drawn, formed or spun articles requiring stiffness.	Corrugated roofing, and flat, drawn or mildly-formed articles requiring maximum stiffness.
	Generally any drawn, formed or spun article not requiring stiffness.	Generally any drawn, formed or spun article requiring some rigidity.			

[1] *Where two figures separated by a comma are given, the first represents strength in direction parallel to the grain; the second, perpendicular to grain.*

Prepared with the assistance of The New Jersey Zinc Co.

News about UNICHROME Trade Mark COATINGS for METALS

New Plastic Coating Compounds

DEFY HARD, CORROSIVE SERVICE!

. . . provide tough, thick coatings that have elasticity and high chemical resistance

SUGGESTED USES: Parts and surfaces of equipment exposed to strong chemical attack.

Unichrome "4000 Series" Compounds, a group of vinyl-base liquids and pastes, are easily applied to metals. When baked into solid form, the unique combination of properties of these plastisols and organosols assures long service under severest conditions.

Often, Unichrome "4000 Series" Compounds will enable you to use lighter or less costly metals for parts requiring resistance to many of the strongest corrosives. Mineral acids (some up to 50% concentration) for example. Also oils, alkalies, salts, water. Even such active oxidants as chromic acid. The coatings do not contaminate.

Cured compounds have good tensile strength – resist abrasion and "bumping." Important, too, is their *workability*. Spraying or dipping gives you a coating from .003" to 3/16", depending on method of application, with only one application.

One more point. The physical properties of these compounds can be modified from soft and elastic to relatively hard and rigid. So if you want a coating compound to meet *your* specifications – on corrosion resistance, on resilience, on method of application – contact headquarters for "Coatings for Metals." Tell us your requirements.

UNICHROME Trade Mark

UNITED CHROMIUM, INCORPORATED
100 East 42nd St., New York 17, N. Y.
Detroit 20, Mich. • Waterbury 90, Conn.
Chicago 4, Ill. • Los Angeles 13, Cal.
In Canada:
United Chromium Limited, Toronto, Ont.

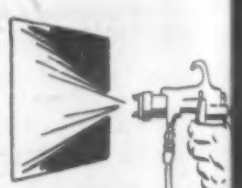
For a zinc finish that stays bright

Because it gives zinc plate a brilliant lustre, protects it from corrosion, and costs so little, Unichrome Dip Finish is being used extensively on refrigerator shelves today...as well as on other wire goods, die castings, screws, nuts, bolts.

New primer for magnesium and aluminum

Hard-to-coat metals such as magnesium and aluminum get a finish that really sticks when coated with Unichrome Primer AP-10. Not only does this organic primer promote adhesion, but it also provides extra corrosion-resistance and increases durability of top coats used.

Yes . . . a HARD finish can also be FLEXIBLE



Unichrome Coating B-115 is an exceptionally clear, baking synthetic finish that can be used on strip and sheet prior to fabrication. For in addition to adhering despite flexing, and forming operations, it also has the hardness to resist abrasion.

New Materials and Equipment

Materials

High-Purity Vanadium

High-purity, ductile vanadium metal is now available in limited quantities for fabrication and use by the metal industry from the *Electro Metallurgical Div.* of *Union Carbide & Carbon Corp.* The metal is said to average above 99.8% vanadium, and can be obtained in ingots, bars, sheet, foil, and in the form of chips for remelting

New high-purity vanadium metal is now available in the form of ingots, plates, bars, sheet and strips, as well as chips for remelting.

into ingots of special sizes and shapes.

Pure vanadium has good corrosion resistance, high tensile strength and excellent ductility. It is highly resistant to corrosion by salt spray, sea water and reducing acids in moderate concentrations, and tests to date indicate that it has good anti-fouling characteristics.

Vanadium metal has a modulus of elasticity of about 22 million psi. and a density of 6.1 g. per cu. cm. In ingot form, it can be hot-rolled at temperatures between 1475 and 2100 F. Rolling practice, with respect to passes and reduction, follows that established for austenitic stainless steels. Sheet bar stock does not work-harden appreciably even during cold working and can be rolled to a sheet having a thickness of 0.020 in. In fact, it is claimed that a reduction of 85% can be made without intermediate annealing.

The machinability of vanadium is about the same as that of cold-rolled steel. High cutting speeds can be used to produce good surface finishes on this free cutting and easily-machinable metal.

Vanadium has good workability and can be formed, bent, stamped and pressed in the usual manner. Possessing good welding characteristics, it can be welded by the Heliarc process, using an argon atmosphere for shielding.

Nickel-Clad Wire

Said to combine durability and toughness with good electrical characteristics, a wire composed of a copper core and an outer layer of nickel, which comprises one-third of the wire's cross-section, is being produced by *Alloy Metal Wire Co., Inc.,* Prospect Park, Pa.

Outstanding advantages of nickel-clad copper conductor are claimed to be its strength, corrosion resistance, and resistance to high temperature failure. Its electrical conductivity is 70% that of copper alone.

Nickel-clad copper is already used for lead wires, electronic tubes, electrical appliances, infra-red drying ovens, electrical resistance and induction furnaces, and connecting lines between power supply and electric equipment where high temperatures would oxidize other commonly used metals. Excellent corrosion resistance is said to make it ideal for fixture wire in chemical plants, refineries, plating, and pickling departments.

The conductor is available in rods from 0.031- to ½-in. dia. and in round and flat wire, coils or spools, solid or stranded, in all standard sizes.

Insulating Material

Originally developed for use in jet engines and tail pipes, a new high silica content, all mineral insulation is now available to all industries from the *H. I. Thompson Co.,* 1733 Cordova St., Los Angeles 7.

Called Refrasil, the insulation is said to withstand temperatures of 2000 F indefinitely, and as much as 500 F higher for periods of short duration. Another advantage claimed for Refrasil is extreme chemical stability. It is unaffected by ordinary acids and can be placed in contact with metal surfaces at 2000 F for an indefinite period without chemical union.

Refrasil is available in bolts, cloths, tapes, sleevings, cordage and loose fiber, and in prefabricated blankets or other ap-

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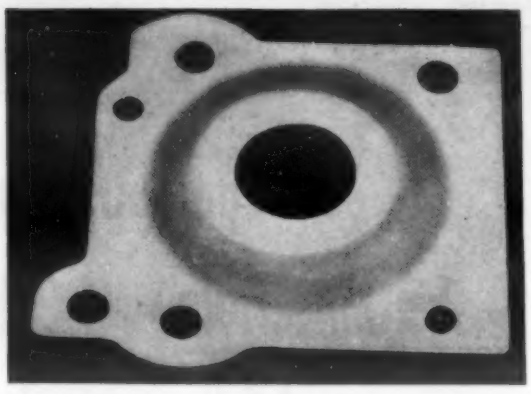
New Materials and Equipment
(CONTINUED)

plications, either with or without foils and other reflecting, insulating or binding materials.

Silicone-Coated Acrylic Fabric

One of the newest industrial materials made from du Pont's new fabric, Orlon, is the Cohrlastic 3500 series of silicone rubber-coated Orlon, fabricated by the *Connecticut Hard Rubber Co.*, 407 East St., New Haven 9, Conn.

Properties of Cohrlastic 3500—impermeability, heat and cold resistance, good dielectric strength and high tensile strength—indicate its use in many industrial applications. But it is said to be so outstanding as a diaphragm material that practically all of the material made to date has gone into that field. These diaphragms may be flat or



Cohrlastic 3500 is supplied as a fabric or in the form of finished diaphragms, as shown here.

convoluted, are light and strong, and operate from −75 to 300 F. More important, they are extremely flexible, have a long flex life, and are said to be particularly useful where pressure differentials are low and quick response to a slight change is desired.

Saran-Lined Valves

Saran-lined Grinnell-Saunders diaphragm valves for handling corrosive fluids and gases have been developed by the *Dow Chemical Co.* of Midland, Mich.

Special castings designed for the purpose are lined with B-115 saran, the same material used in saran lined pipe and fittings. Although furnished normally with diaphragms of Saran rubber, diaphragms of natural rubber, Neoprene, butyl, Hycar and white Neoprene are supplied optionally for special conditions.

Available in sizes from 1 to 6 in., inclusive, the valves have flanged ends and are usually equipped for hand-wheel operation, although quick-opening lever operators, electric motor and air motor operators are readily available.

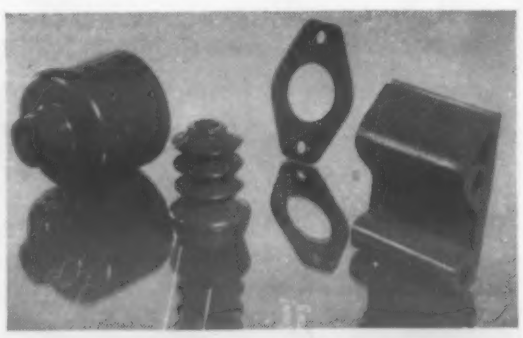
The valves are distributed by Saran Lined Pipe Co., 2415 Burdette Ave., Ferndale 20, Mich.

Parts & Forms

Silicone Rubber Parts

A large variety of molded, extruded, punched and lathe or die-cut parts fabricated from the new Silicone 161 rubber compound is now available from the *Stalwart Rubber Co.*, 165 Northfield Rd., Bedford, Ohio. Because this new compound can be fabricated more quickly and easily than previously developed silicone rubber, the cost of production parts is said to have been considerably reduced.

Silicone 161 rubber parts have a tensile strength of from 470 to 520 psi., elongation of 110 to 160%, and a specific gravity of 2.1. These parts will not become brittle and crack after long exposure to air, ultraviolet rays, or ozone. Used to replace metal constructions which have been required because of limited thermal stability of organic rubber, the parts are claimed to resist carbonization under the influence of extreme heat.



Shown above are only a few of the large variety of Silicone 161 rubber parts now available to industry.

Pressed-Fit Pin

The Rollpin, a new product of *Elastic Stop Nut Corp.*, 2330 Vauxhall Rd., Union, N. J., is an all-purpose pressed-fit pin which introduces a new idea of design and application in metal fasteners. A self-locking pin with chamfered ends, the Rollpin

In this feed tube finger clutch assembly for single- and multi-spindle automatic screw machines, the Rollpin holds the actuating finger in place. The finger and Rollpin are shown, disassembled, at the right.

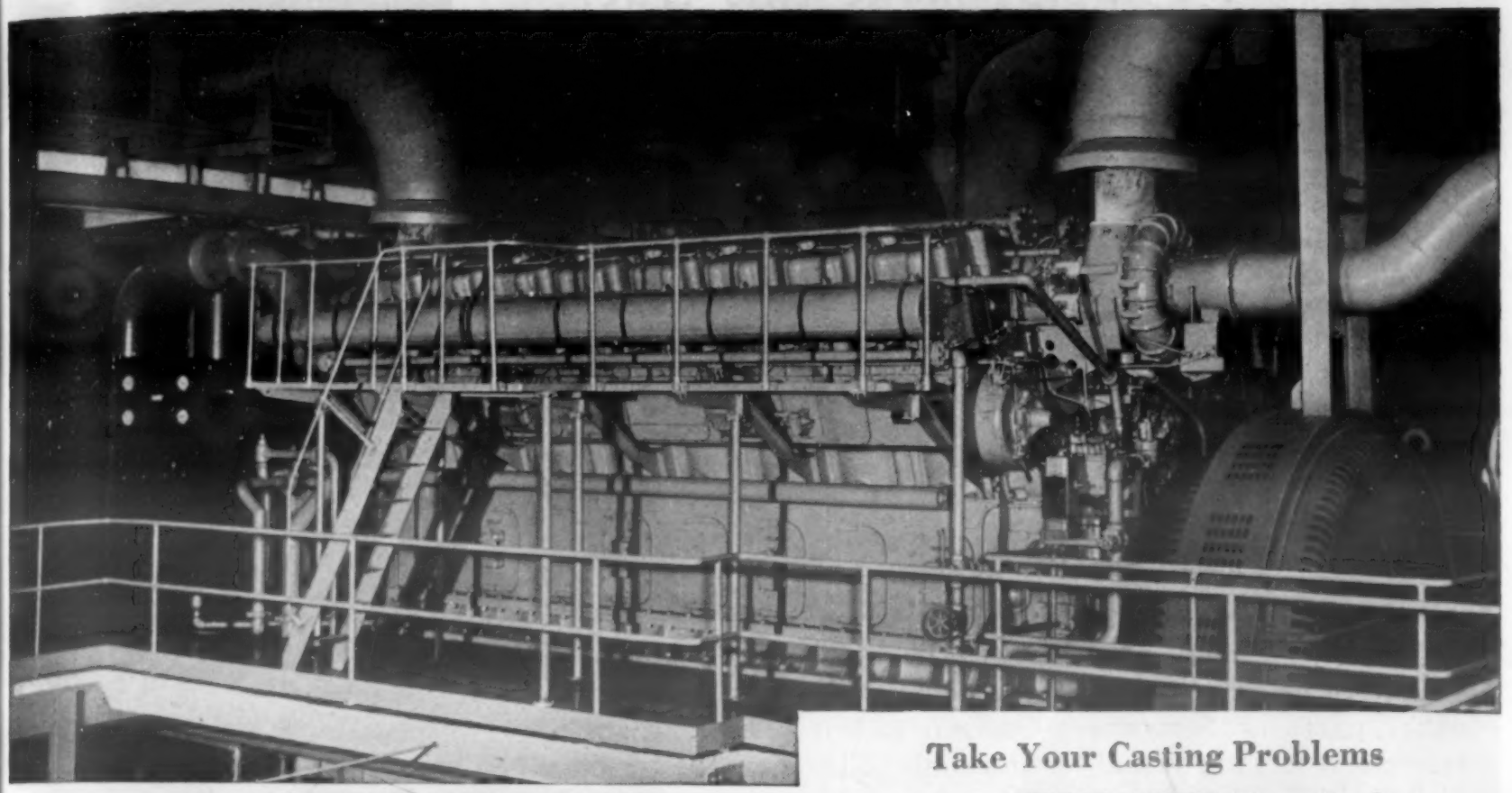
has been engineered to replace the variety of dowel, pivot, tapered and grooved pins which ordinarily require a key or some supplementary method to hold them in place.

Use of the pin is claimed to make possible greatly simplified industrial design of such varied equipment as an ordinary tacker, the lubrication pump assembly of a diesel engine, the vent window handle on an automobile, or an important assembly in a 35-mm. projector for television.

Actually, the Rollpin is a piece of metal rolled into the shape of a hollow cylinder with a gap or slot which parallels the axis. Both ends of the cylinder are chamfered, or beveled, so the pin can be driven and compressed into a hole that is, by design,

COOPER-BESSEMER DIESELS
ELLIOTT-BUCHI TURBOCHARGERS
MEEHANITE® CASTINGS

COMBINED



TO ASSURE EFFICIENCY DEPENDABILITY QUALITY

The Cooper-Bessemer 16-cylinder gas Diesel engine equipped with Elliott-Buchi Turbochargers provides a power combination which results in the last word in efficiency and dependability. The unit delivers more horsepower per square foot of floorspace than any known comparable engine.

As manufacturers of this type of quality equipment the designers and engineers of both the Elliott Company, Jeannette, Pa. and The Cooper-Bessemer Corporation, Mt. Vernon, Ohio, recognize the importance of component materials;—materials which can provide superior and dependable engineering characteristics and uniformity. For these reasons both companies manufacture Meehanite castings and use them for such important parts as follows:

COOPER-BESSEMER DIESEL

Pistons
Cylinder Liners
Cylinder Heads
Blocks, Centerframes, Bases

ELLIOTT-BUCHI TURBOCHARGER

Turbine Casings
Back Plates
Blower Casings

Those listed represent the more important castings upon which performance and quality depend. Many others, less vital parts,—in fact all iron castings are Meehanite metal produced under Meehanite controlled processes.

Study your designs and requirements and when you want to be *sure*—specify Meehanite castings.

Take Your Casting Problems to a MEEHANITE Foundry!

American Brake Shoe Co. ..... Mahwah, New Jersey
The American Laundry Machinery Co. ..... Rochester, New York
Atlas Foundry Co. ..... Detroit, Michigan
Banner Iron Works ..... St. Louis, Missouri
Barnett Foundry & Machine Co. ..... Irvington, New Jersey
E. W. Bliss Co. ..... Hastings, Mich. and Toledo, O.
Builders Iron Foundry ..... Providence, Rhode Island
Continental Gin Co. ..... Birmingham, Alabama
Crawford & Doherty Foundry Co. ..... Portland, Oregon
The Cooper-Bessemer Corp. ..... Mt. Vernon, Ohio and Grove City, Pa.
Farrel-Birmingham Co., Inc. ..... Ansonia, Connecticut
Florence Pipe Foundry & Machine Co. ..... Florence, New Jersey
Fulton Foundry & Machine Co., Inc. ..... Cleveland, Ohio
General Foundry & Manufacturing Co. ..... Flint, Michigan
Greenlee Foundry Co. ..... Chicago, Illinois
The Hamilton Foundry & Machine Co. ..... Hamilton, Ohio
Johnstone Foundries, Inc. ..... Grove City, Pennsylvania
Kanawha Manufacturing Co. ..... Charleston, West Virginia
Koehring Co. ..... Milwaukee, Wisconsin
Lincoln Foundry Corp. ..... Los Angeles, California
E. Long Ltd. ..... Orillia, Ontario
Otis Elevator Co., Ltd. ..... Hamilton, Ontario
The Henry Perkins Co. ..... Bridgewater, Massachusetts
Pohlman Foundry Co., Inc. ..... Buffalo, New York
The Prescott Co. ..... Menominee, Michigan
Rosedale Foundry & Machine Co. ..... Pittsburgh, Pennsylvania
Ross-Meehan Foundries ..... Chattanooga, Tennessee
Shenango-Penn Mold Co. ..... Dover, Ohio
Sonith Industries, Inc. ..... Indianapolis, Ind.
Standard Foundry Co. ..... Worcester, Massachusetts
The Stearns-Roger Manufacturing Co. ..... Denver, Colorado
Traylor Engineering & Mfg. Co. ..... Allentown, Pennsylvania
Valley Iron Works, Inc. ..... St. Paul, Minnesota
Vulcan Foundry Co. ..... Oakland, California
Warren Foundry & Pipe Corporation ..... Phillipsburg, New Jersey

"This advertisement sponsored by foundries listed above."

MEEHANITE®

New Rochelle, N. Y.

"There is nothing finer than a Stromberg Carlson"—

Luster-on®

helps make this true!

Modern equipment and exacting control methods contribute to Stromberg-Carlson quality. Here S-C Television Chassis Shields emerge from automatic plating machine. Note brilliant Luster-on finish.

Brilliant — *permanently* impervious to finger marks, corrosion or other stains, the speaker frame, chassis and other parts of Stromberg-Carlson radio, telephone and television sets are visual testimonials to the new Luster-on Utility 25 Dip.

Stromberg-Carlson's selection of Luster-on for its zinc-plated parts is characteristic of its insistence that the product live up to its slogan.

Luster-on Utility 25 can improve the appearance and life-expectancy of any zinc-plated product while substantially reducing costs for any user of competitive bright dips or cadmium plate.

Stromberg-Carlson Production Engineer Fred Ciambrone, shown with Materials Engineer C. F Van Epps and his assistant, Edwin Wallin, says: "We agreed on Luster-on Utility 25 for our zinc finish because it met our strictest requirements for salt spray corrosion resistance, gave a beautiful, clear brilliance, was fast, easy and reliable to use and offered us a new economy with high quality standards."

Send for full details today on

New Luster-on® *Utility 25*

Manufactured and distributed in Canada by

ALLOYCRAFT LIMITED
27 Hillside Ave., Westmount
Montreal 6, P. Q.

THE *Chemical* CORPORATION
54 Waltham Ave., Springfield 9, Mass.

THE CHEMICAL CORPORATION
54 Waltham Ave., Springfield, Mass.

Please send me full particulars about Luster-on Utility-25 for zinc-plated surfaces. I am (am not) sending sample for free dip. No obligation, of course.

Name.....

Firm.....

Address.....

New Materials and Equipment

smaller than the diameter of the pin. The slot permits compression of the cylinder as the pin is driven in, and the resulting tension, caused by the constant pressure exerted by the Rollpin against the walls of the hole, is said to secure it in position against extreme vibration and shock.

Simply and rapidly inserted with hand tools or automatic jig assemblies, the Rollpin retains its locking characteristics through repeated insertions, and its shear strength exceeds that of a solid cold rolled pin of equal diameter.

Rollpins are made from SAE 1095 steel and Type 420 stainless steel, and although the standard Rollpin is not plated, plated finish may be specified. Pins are also made from beryllium copper, but are not generally available from stock in this material.

Seamless Aluminum Cable Sheathing

A method for applying a seamless sheathing of aluminum to telephone and electric power cables has been developed by *Aluminum Co. of America,* Pittsburgh 19, Pa. This new method involves the principle of cold reduction or swaging.

Seamless aluminum sheathing for cable is said to be thinner, stronger and lighter in weight than the usual lead sheathing. These advantages are obtained both because aluminum has about one-fourth the density of lead and because aluminum, with its higher yield and tensile strengths, can be applied in approximately one-half the thickness required of lead.

The new product is said to be softer and more flexible than similar aluminum sheathing produced previously.

Chemical Process Resin Parts

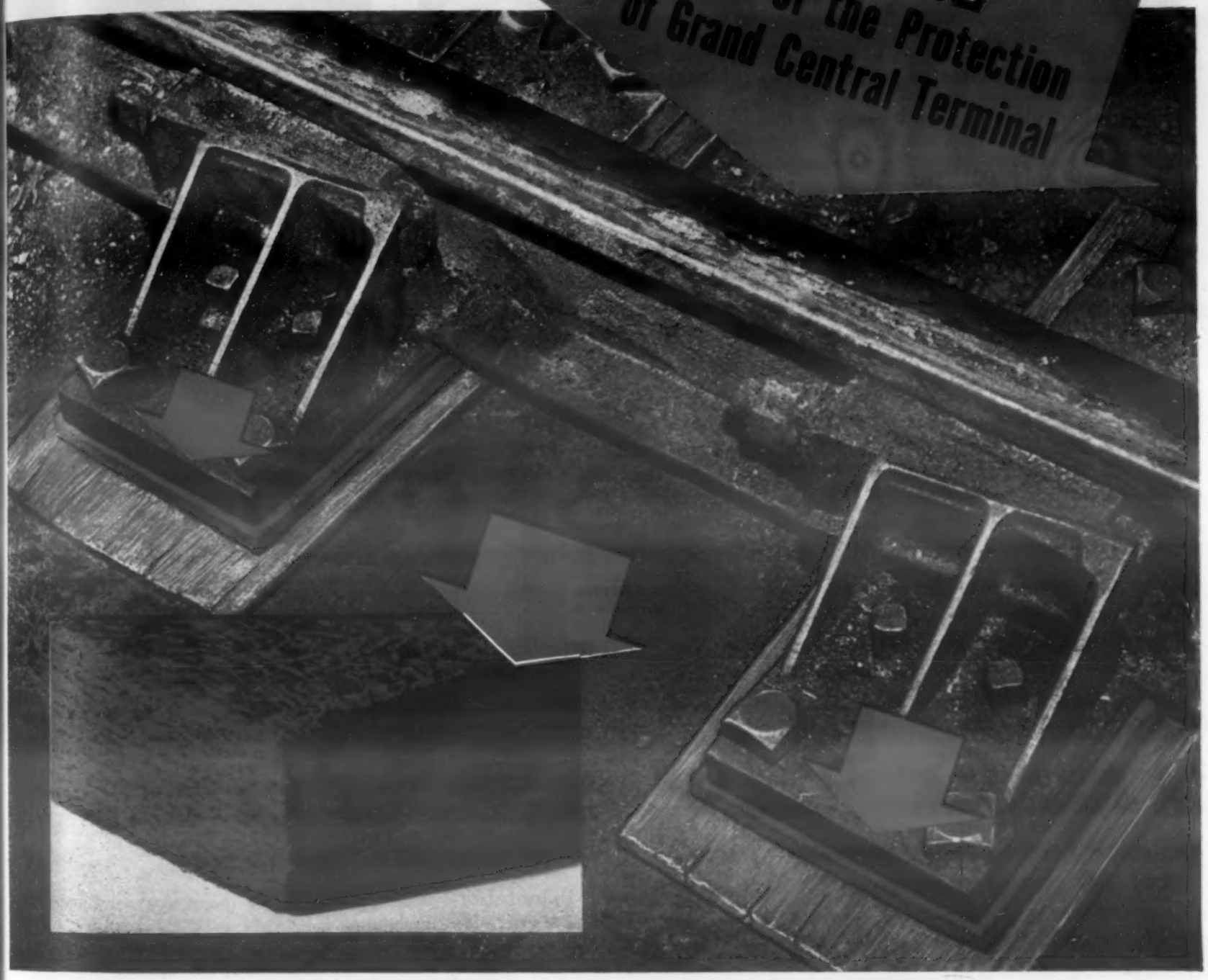
A new line of chemical process equipment, made of synthetic resins and designed to meet stringent corrosion resistance requirements, is being produced by the *General Ceramics & Steatite Corp.,* Keasby, N. J.

Trade-named Kemplas, the new equipment is made of modified phenolic resins produced by *Pennsylvania Salt Manufacturing Co.,* 1337 Chestnut St., Philadelphia.

The resins are either cold cast or laminated with glass cloth and molded into desired shapes and are said to be particularly suitable to form strong, dense castings where tensile strength is not an important factor, such as in pump volutes, impellers

FELT
is part of the Protection of Grand Central Terminal

Close-up of tie plate and felt pad. The facilities of Grand Central Terminal are shared by The New York Central and the New York, New Haven & Hartford, two of America's great railroads, serving our five plants.



● Passengers who use the famous Grand Central Terminal in New York City never know that they are riding on felt, but such is the case. Felt pads are installed under the tie plates that hold the rails to the ties. Felt is used here to lessen the transmission of vibration to the structure of the Terminal, which has tracks on two levels, one above the other. In this application, felt probably meets its most severe test in vibration control. Another function of the felt is to reduce noise. Felt by American serves perfectly here, and lasts amazingly long, even under loads running as high as 25,000 pounds on each electric locomotive driving wheel. Replacements have been due chiefly to changes in rails and in tie plate design—the felt in some cases actually lasts as long as the steel rails!... If you have a problem in vibration control, get in touch with American Felt or any of its Sales Offices.

American Felt Company

TRADE MARK

GENERAL OFFICES: 24 GLENVILLE RD., GLENVILLE, CONN.—ENGINEERING AND RESEARCH LABORATORIES: GLENVILLE, CONN.—PLANTS: Glenville, Conn.; Franklin, Mass.; Newburgh, N. Y.; Detroit, Mich.; Westerly, R. I.—SALES OFFICES: New York, Boston, Chicago, Detroit, Cleveland, Rochester, Philadelphia, St. Louis, Atlanta, Dallas, San Francisco, Los Angeles, Portland, Seattle, Montreal.

HOW CAN YOU TEST THE HARDNESS OF...

... a .003″ diameter wire?

... internal surfaces of cylinders?

... parts weighing hundreds of pounds?

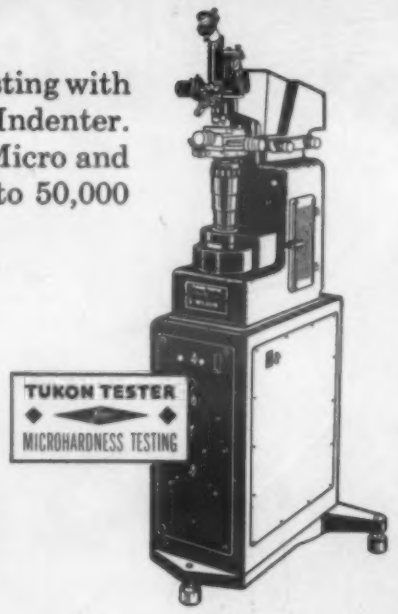
... individual constituents of alloys?

... sheets only .001″ thick?

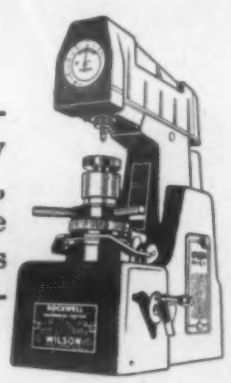
... gear teeth on the pitch line?

Simple, every-day jobs with WILSON HARDNESS TESTING EQUIPMENT

TUKON—for micro-indentation hardness testing with either Knoop or 136° Diamond Pyramid Indenter. Made in 3 models to cover the full range of Micro and Macro Hardness testing with loads from 1 to 50,000 grams.



"ROCKWELL" HARDNESS TESTER developed and made only by Wilson. For laboratory, toolroom or production line testing. Vertical capacities from 3¼″ to 16″. Motorized models available.



"ROCKWELL" *Superficial* HARDNESS TESTER—especially suited for testing thin material, nitrided or lightly carburized steel and areas too small for regular "ROCKWELL" Hardness Tests. Depth of indentation .005″ or less. Satisfactory for general testing where surfaces are smooth and materials homogeneous.

ACCESSORIES "*BRALE*" is the only diamond indenter made to Wilson's precision standards. • *TEST BLOCKS*—enable you to keep your instrument "Laboratory" accurate. • *EQUITRON*—fixture provides means for accurately positioning test samples. • *ADAPTER*—permits testing inner cylindrical surfaces with unimpaired accuracy. • *WORK SUPPORTS*—facilitate testing of variously shaped rod stock, tubing or irregular shapes.

VISIT OUR BOOTH NUMBER **519** AT THE METAL SHOW

WILSON MECHANICAL INSTRUMENT CO., INC.

AN ASSOCIATE COMPANY OF AMERICAN CHAIN & CABLE COMPANY, INC.

230-E PARK AVENUE, NEW YORK 17, N. Y.

ACCO

New Materials and Equipment

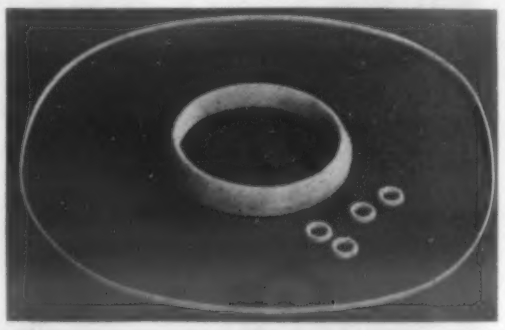
and some pipe fittings. In addition, the resins are said to be completely stable up to 370 F, although the recommended maximum operating temperature is 350 F.

Equipment made of the material is capable of withstanding all atmospheric conditions and can operate under a wide range of temperatures without being subject to thermal shock, according to the manufacturer.

Teflon Molded Parts

Certain of the design limitations formerly placed on Teflon moldings have been overcome by new molding techniques developed by the *Connecticut Hard Rubber Co.*, 407 East St., New Haven 9, Conn.

These techniques give greater density, less porosity, and permit molding of large



Shown above are some of the new Teflon molded parts made possible by new molding techniques.

and rather thin pieces to closer dimensions than previously attained, according to the manufacturer.

Teflon's ability to operate within the temperature range of –100 to 265 F and to resist practically all chemicals makes it an ideal material for gaskets and seals in chemical and petroleum plants, in diesel and aircraft engines, and wherever difficult operating conditions exist.

Chemical Dipper

A greatly increased safety factor in handling corrosive liquids is made possible by a new type dipper for use with a variety of chemicals, according to the manufacturer, *Stokes Molded Products, Inc.*, Trenton 4, N. J.

Made of Stokolite L-44 compound, which has a base of virgin rubber, the new dipper is streamlined for lightness and has an efficient pouring lip and a well-reinforced handle. The nature of the material gives it unusually high resistance to shock, abrasion,

Versatile Tools

FOR spectrochemical analysis...

For studies of the information carried by light, Kodak offers more than a hundred different varieties of spectroscopic plates and films. Ten emulsion types offer choices of sensitivity, contrast, and granularity. Eighteen kinds of spectral sensitization provide sensitivity regions everywhere in the range from 240mμ to 1200mμ.

For general spectrum analysis in the range from 240mμ to 440mμ, two emulsions are particularly useful:

Kodak Spectrum Analysis No. 1 Emulsion is designed for precision in quantitative analysis.

It has higher contrast than the usual process plates and films, low background density, low granularity. It can be processed in two and one-half minutes, dry and ready to read.

Kodak Spectrum Analysis No. 2 Emulsion is preferred for trace detection.

It has lower contrast, higher speed, wider latitude. Its more uniform contrast over the 240mμ-440mμ range permits fewer calibration lines in approximate quantitative work.

These materials and others are described in a new booklet, "Sensitized Materials for the Scientific and Industrial Laboratory." Write for a copy.

EASTMAN KODAK COMPANY
Industrial Photographic Division
Rochester 4, N.Y.

Kodak
TRADE-MARK

MEET AMMONIA'S

Thrifty Twins

FROM DISSOCIATED AMMONIA

Each cylinder or tank car of Barrett Standard Anhydrous Ammonia (REFRIGERATION GRADE) is a low-cost source of two gases—HYDROGEN and NITROGEN. When dissociated, one pound produces approximately 34 cubic feet of hydrogen and 11 cubic feet of nitrogen.

You save money by using dissociated ammonia in the production of controlled atmospheres in furnaces for bright annealing, clean hardening, copper brazing, sintering, reduction of metallic oxides, atomic hydrogen welding, radio tube sealing and other metal-treating practices.

Anhydrous ammonia also has unsurpassed qualities in the nitriding of steel, used as ammonia gas or dissociated.

Barrett Standard Anhydrous Ammonia is available in 150, 100 and 50-pound cylinders from stock points conveniently located from coast to coast; or, for larger users, in tank car shipments from Hopewell, Virginia, and South Point, Ohio.

The advice and assistance of Barrett technical men are readily available. For information, contact Barrett, *America's leading distributor of ammonia.*

THE BARRETT DIVISION
ALLIED CHEMICAL & DYE CORPORATION
40 RECTOR STREET, NEW YORK 6, N. Y.

Barrett*

*Reg. U. S. Pat. Off.

New Materials and Equipment

heat, and chemical corrosion—which is said to render it practically indestructible.

Chemicals with which it has been successfully tested for corrosion resistance are said to include an extensive list of acids, salts, bases and organic materials under varied atmospheric and temperature conditions.

Tote Boxes

A stacking and nesting tote box that is formed in one seamless piece from Royalite thermoplastic material is now available from *United States Rubber Co.*, Rockefeller Center, New York 20. Handles are formed into the roll of the upper lip so that the tote box can be picked up from any side and all corners are rounded.

The Royalite tote box is designed for criss-cross stacking, enabling the contents of each to be seen even when stacked. Adequate locking prevents the boxes from slipping or sliding from the stack.

Requiring little space, the tote boxes are light, easy to handle, and easy to clean. They are claimed to be extremely tough, acid resistant and non-toxic, with high resistance to impact and low water absorption —less than one-half of 1%.

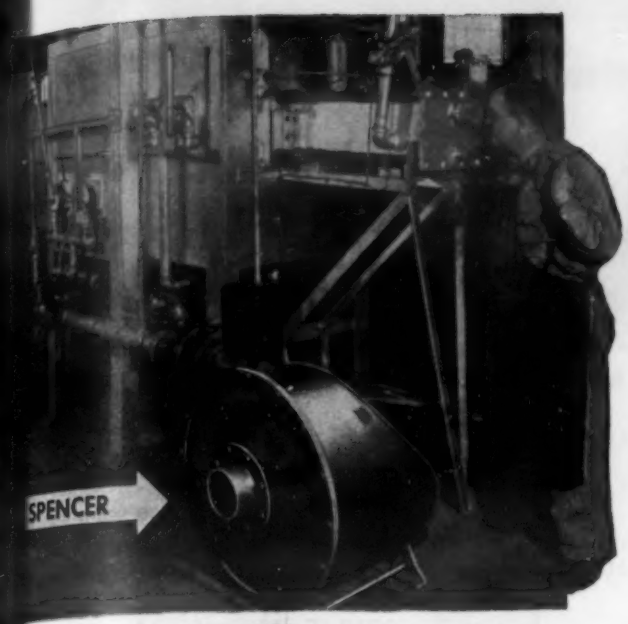
In addition to use by industrial plants, the tote boxes are said to be practical for such varied applications as meat packing, dish boxes for restaurants and hotels, and acid tanks.

Coatings & Finishes

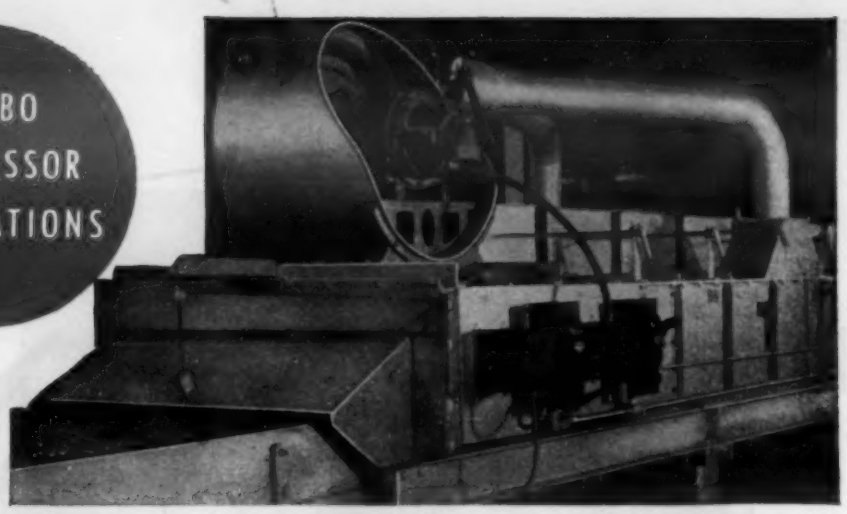
Bonding Primer

A quick-drying and flexible primer for all metal finishes has been developed by *Michigan Chrome & Chemical Co.*, 6338 E. Jefferson Ave., Detroit 7. Called Miccroloid Primer, it is said to provide maximum adhesion on metals such as brass, tin, lead, galvanized metal, zinc, steel, cadmium, magnesium, aluminum and bronze.

The primer, acting as a rust inhibitor, protects metal before painting by forming insoluble phosphates at the metal surface, and is also used as a metal-surface-conditioning agent to replace conventional acid wash coats. It can be applied by spraying, dipping or brushing.



TURBO COMPRESSOR APPLICATIONS

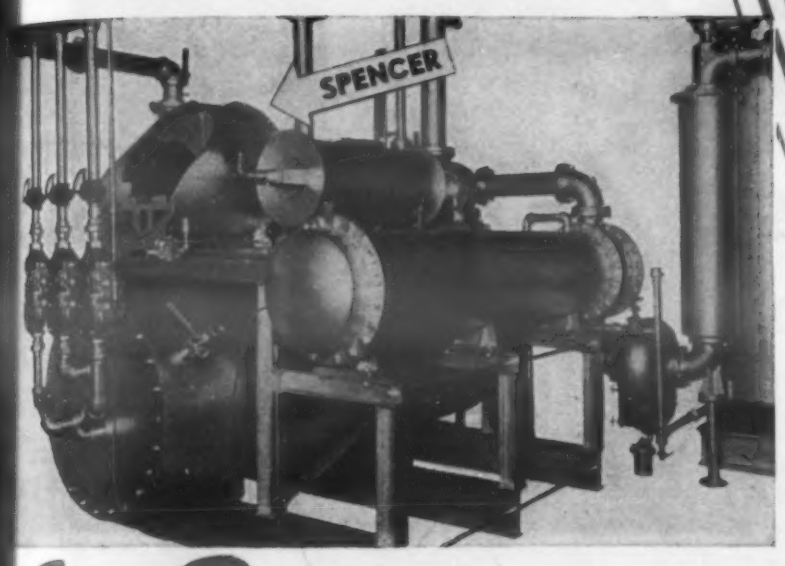


Ask for the Spencer Turbo Data Book and any of the bulletins mentioned.

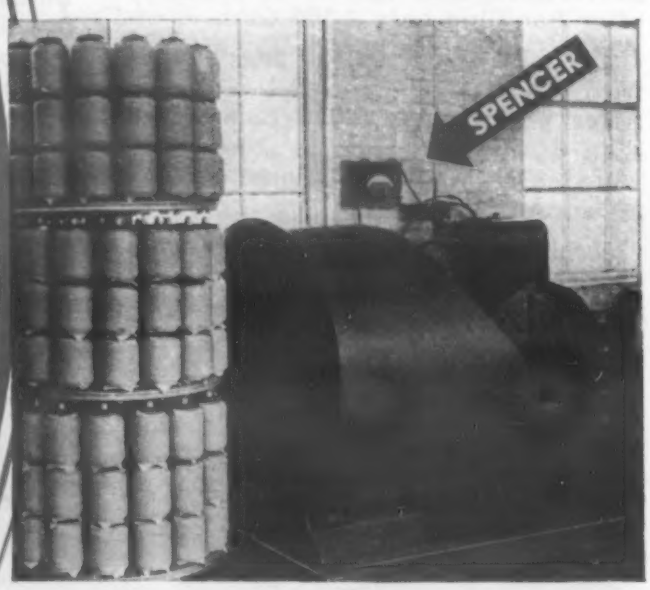
Cooling
BULLETIN No. 127

Heat Treating
BULLETIN No. 126

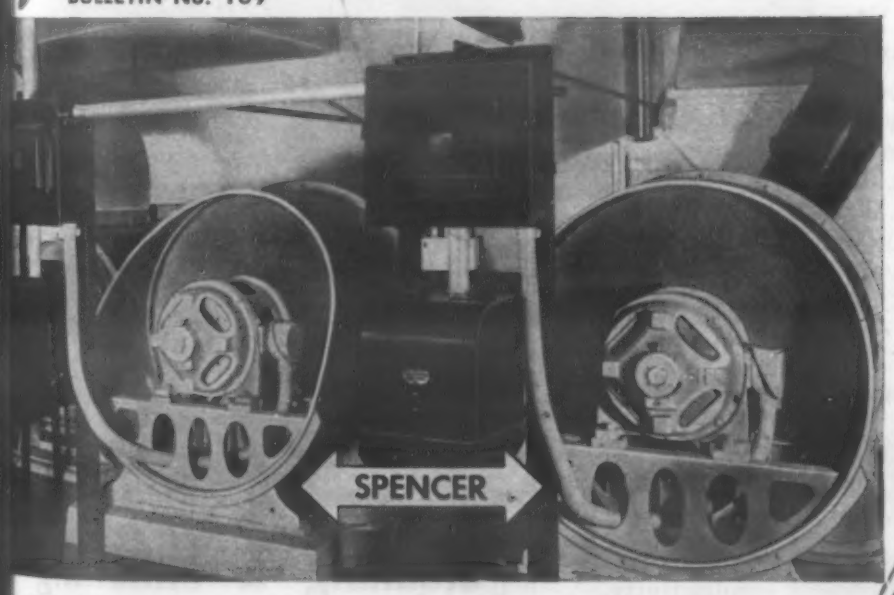
Foundry
BULLETIN No. 112



Gas Booster
BULLETIN No. 109



Blowing
BULLETIN No. 127



Pneumatic Tube
BULLETIN No. 104

See Spencer at Booth No. 1019

3596

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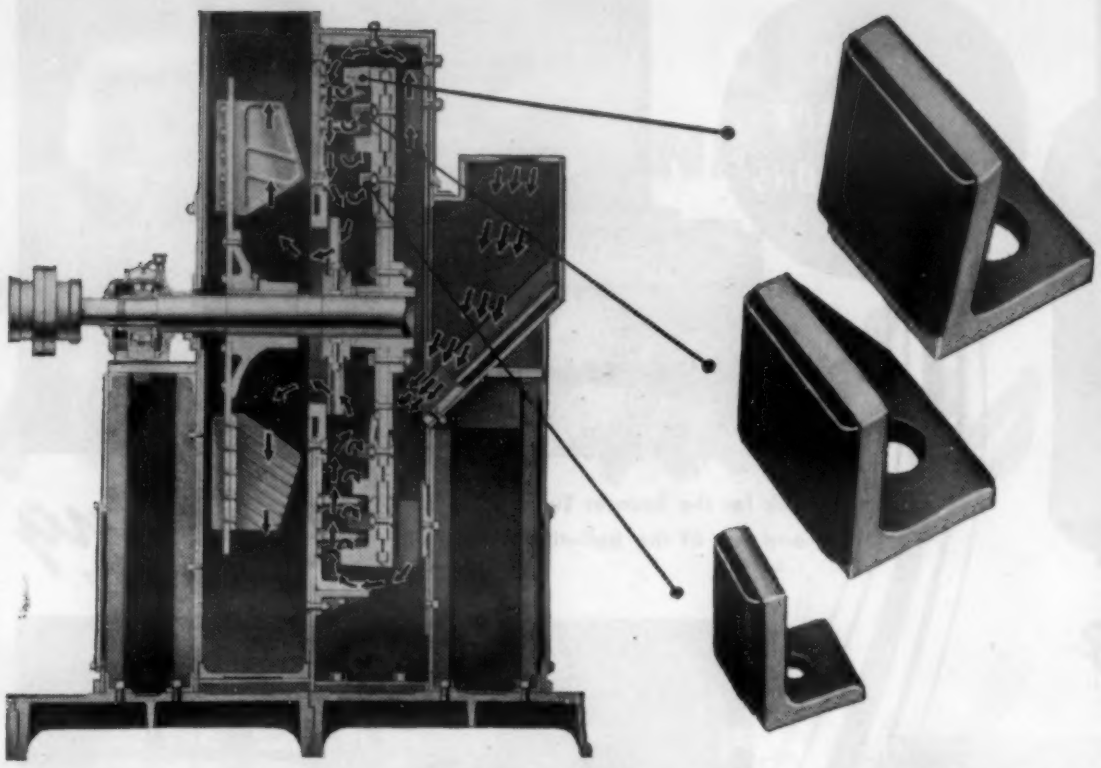


Life of Coal Pulverizer Pegs increased 6 times

by Wear-Resistant Carboloy

. . . and they're still going strong!

STEEL couldn't stand the grind when it came to pulverizing "soft" coal. When an industrial stoker manufacturer used steel "pegs" on rotary coal pulverizers, they had to be replaced after handling only 3,500 tons.

Then he switched to "pegs" faced with Carboloy Cemented Carbide. After pulverizing 22,000 tons—more than 6 times as much as steel—they were still going strong and showed no appreciable wear.

Everyone gained through this change to Carboloy. The stoker manufacturer came up with a powerful, new selling point. Users saved time and money through continuous operation of boilers. There were no shutdowns to replace "pegs", no time was lost for maintenance.

Carboloy is working similar wear-proofing miracles in dozens of industries. This *hardest metal made by man* was developed specially to combat wear. In some cases it has increased the life of machine parts or products by *as much as 100 times.*

There's a good chance that Carboloy can eliminate costly downtime and parts replacement in your machines, or add extra life and efficiency to your products. Write today and arrange for a Carboloy engineer to call and talk things over. Carboloy Company, Inc., 11161 E. 8 Mile Ave., Detroit 32, Michigan.

Where Can You Use These Outstanding Characteristics of Carboloy?

1. Hardness
2. Compressive strength
3. Abrasion resistance
4. Corrosion resistance
5. High red hardness
6. Low coefficient of thermal expansion
7. High modulus of elasticity
8. Impact strength
9. High density
10. High polish retention
11. Low electrical conductivity
12. Non-magnetic (if desired)

WHEREVER THERE'S MOTION THERE ~~IS~~ need not be WEAR

CARBOLOY® HARD METAL
CEMENTED CARBIDE
The Versatile Metal of Industry

New Materials and Equipment

Varnish Resin

Modiphat 345, a new varnish resin which is a pentaerythritol ester of resin, fatty acid and maleic anhydride, is being introduced to industry by *General Mills Research Laboratories,* 2010 E. Hennepin Ave., Minneapolis 13, Minn.

When heated slightly, the new resin is said to disperse rapidly in oil, producing rapid-drying varnishes that yield hard, tough films with excellent color and resistance to water and alkali. Modiphat 345 is compatible with dehydrated castor oil, linseed and tung oils, and effectively removes the aftertack of dehydrated castor oils with which it is used, according to the manufacturer. It is also compatible with the phenolics, modified phenolics, and rosin esters.

Although soluble in ethyl acetate, benzol, toluol, xylol and mineral spirits at 68 F and at boiling temperature, it is insoluble in ethyl alcohol under these same conditions.

Zinc Bright Dip

Impressive savings with brighter appearance and more uniform results are advantages claimed by *The Chemical Corp.,* 54 Waltham Ave., Springfield 9, Mass., for its Luster-On Utility-15 zinc bright dip.

This new product can be diluted as much as ten or more times, replenished with the same solution, and still remain exceptionally stable, according to the manufacturer. With it, work can be handled on racks or by bulk dipping, with exceptional uniformity and freedom from iridescence. No noxious fumes are released during the dipping, and no exhaust is required.

Cleaning & Finishing

Plastic Dip Tank

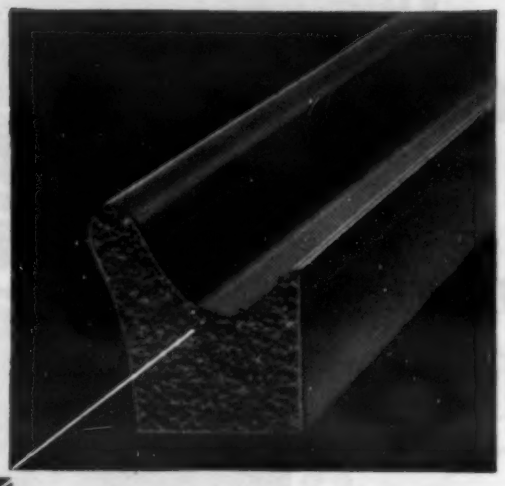
D. C. Cooper Co., 1467 S. Michigan Ave., Chicago 5, has developed a new plastic dip tank for use in coating spare parts for storage and export shipment.

Designed especially for heating cellulose-acetate-butyrate, ethyl-cellulose strip coatings and similar compounds requiring high temperature, the tank is sturdily constructed

An imaginative automotive engineer used

Spongex® cellular rubber

to keep rattles and weather out for greater driving pleasure



Suppose your car doors shut metal to metal! What a *crash* when you slammed them. What squeaks, rattles and groans as you drove along! And you'd get wet. You would freeze. It would *always* be drafty.

But a sponge rubber product seals out drafts, temperature and moisture . . . cushions shock and vibration . . . absorbs noise. Doors shut snugly and quietly, slam after slam after slam.

If you have a vibration, insulation, cushioning, gasketing, sealing or sound damping problem, think about *Spongex*. Cellular rubber does not become a "product" until you make it one in *your* application. We welcome new problems.

Illustration below—The vertical cord is decorative and functional. This fabric covered Spongex cord seals out drafts.

On door and body are Spongex pieces molded around metal to afford reinforcement, rigidity and mechanical fastening.

Spongex forms shown are from molds designed by us and owned by our customers. As such they are not offered for sale. Similar products can be molded to your requirements in molds designed for you.

TECHNICAL BULLETIN ON SPONGE RUBBER AVAILABLE ON REQUEST

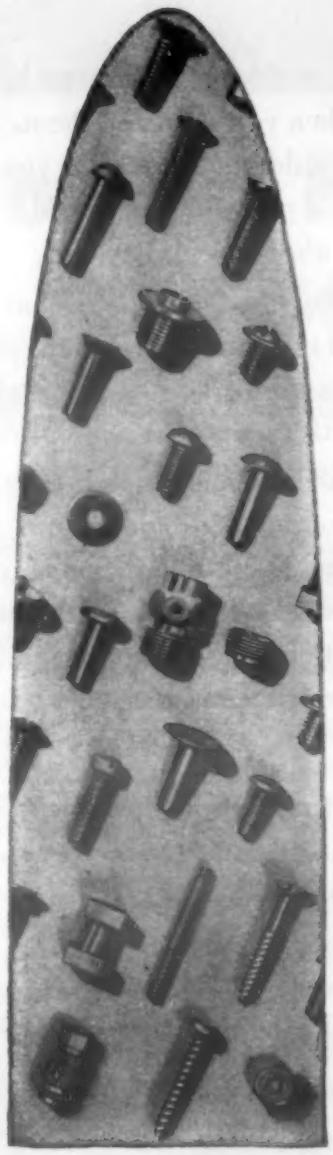
The World's Largest Specialists in Cellular Rubber

THE SPONGE RUBBER PRODUCTS COMPANY

303 Derby Place, Shelton, Conn.

you benefit by

THE CENTURY OF EXPERIENCE BEHIND B&J FASTENINGS



Slotted or Phillips head machine screws, wood screws, stove bolts, tapping screws, special headed products; nuts, rivets, chaplets, wire forms, screw machine products . . . in steel, stainless steel, copper, brass, bronze, everdur, nickel, nickel silver, monel, aluminum . . .

WRITE FOR catalog of complete line of Blake & Johnson fastenings. Address Dept. MM-10.

BLAKE & JOHNSON *Fastenings*

THE BLAKE & JOHNSON COMPANY, WATERVILLE 48, CONN.

New Materials and Equipment

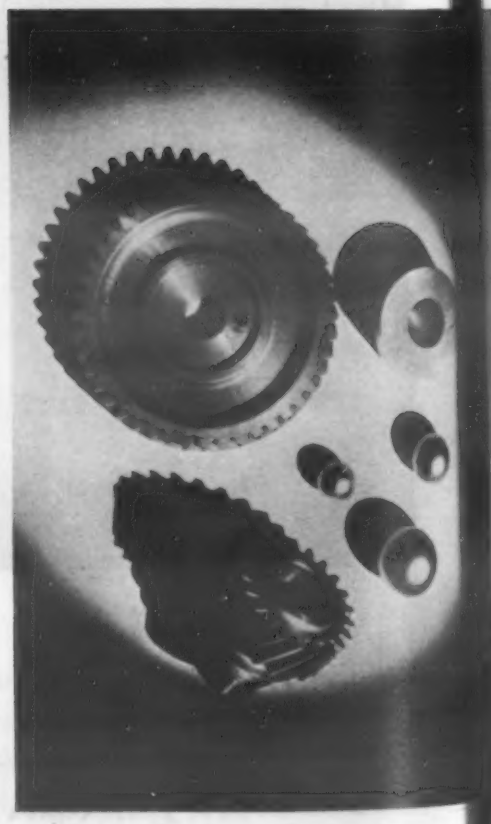
and heavily insulated for economy safety. Electric heating elements of temperature sheath are said to be so pl on the tank as to distribute heat evenly economically throughout, affording uni temperature without overheating, scorc or deterioration of the compound.

Where slow agitation is required, tank is equipped with a special bo agitator for slowly mixing molten pound. A safety device prevents the agi from operating until the compound sufficiently molten.

Tungsten Carbide Sizing Balls

Tungsten carbide balls in sizes f 1/32 to 3 in. in dia. are available f *Industrial Tectonics, Inc.,* Ann A Mich., for accurate sizing of internal ameters.

Extreme hardness, high surface fi

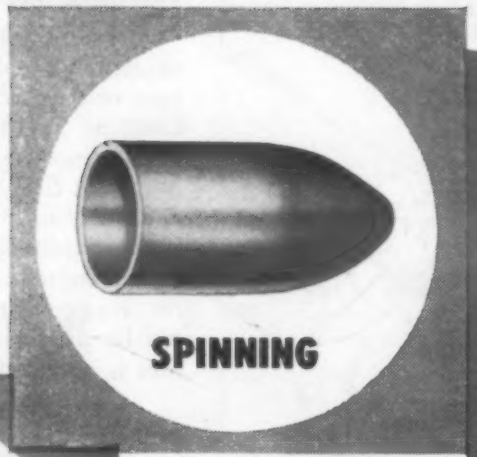


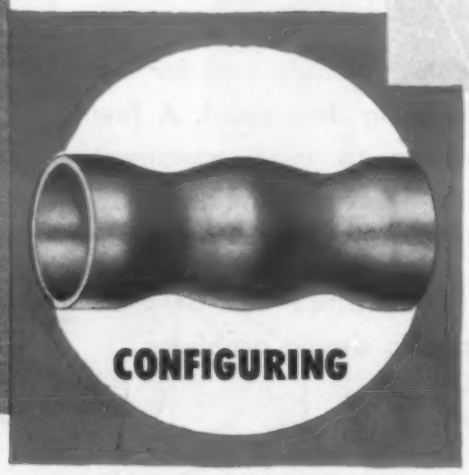
Tungsten carbide sizing balls are said provide accurate size control of inter diameters in addition to low produc costs.

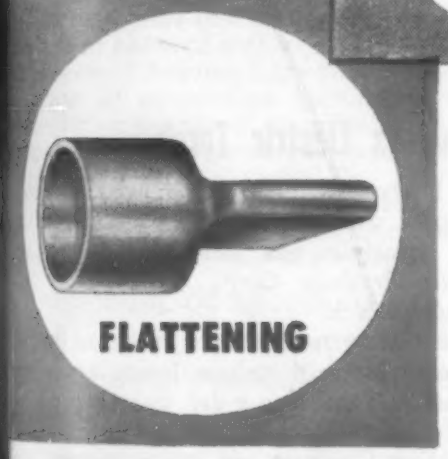
and compression strength of these b are said to result in excellent surface fi and good size control and uniformity the finished part.

Ball burnishing permits inexpensive, tomatic production layouts, employing or hopper feeds for the parts and a circulating set-up for the tungsten carb balls. Even for large volume production,

Severe Fabrication?







ELECTRUNITE TUBING ...Takes it with ease

There's a mighty good reason why ELECTRUNITE Tubing stands out for forming operations like these. It's Republic's ELECTRUNITE Process in which highest quality flat rolled steel is cold formed and welded into strong, sound tubing. As a result every length is uniform throughout—in roundness, diameter, wall thickness and ductility . . . free from defect, inside and out.

Republic ELECTRUNITE Tubing is produced in a full range of sizes, gages and analyses—both carbon and stainless steels. See your nearest Steel and Tubes Representative or write today for a free copy of booklet No. 22.

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Export Department: Chrysler Building, New York 17, N.Y.

Republic
REPUBLIC STEEL ®
ELECTRUNITE TUBING

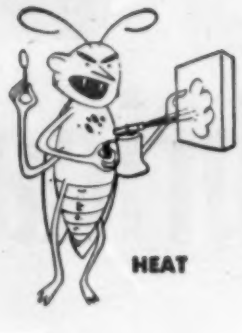
meeting these

"Bugs"

FRICTION

in designing new equipment?

Fight them with
LINDE Synthetic Sapphire!



HEAT

LINDE synthetic sapphire is characterized by a low coefficient of friction, high melting point and hardness, and unusual chemical resistance. Applied in many diverse problems, it has paved the way for a longer trouble-free life, for both small and large parts.

Economical to fabricate, valuable uses for this material are constantly being developed. A few of the many applications to new equipment include: precision balls, sleeve bearings, rods, and orifices.

Call or write any LINDE office for detailed information on your specific design problems.

ELECTRICAL LOSS

CORROSION

WEAR

Chemical Composition	Al_2O_3
Hardness, Knoop's	1525-1660
Melting Point	2030°C.
Dielectric Constant	7.5-10
Coefficient of Friction	0.140
(Steel pivot on sapphire ring)	(0.160 graphite)
Chemical Resistance	Inert to common acids, 30% NaOH at 80°C., and HF at 300°C.

THE LINDE AIR PRODUCTS COMPANY

Unit of Union Carbide and Carbon Corporation

30 E. 42nd St., New York 17, N. Y. UCC Offices in Other Principal Cities

In Canada: DOMINION OXYGEN COMPANY, LIMITED, Toronto

The term "Linde" is a trade-mark of The Linde Air Products Company.

New Materials and Equipment

placement costs for carbide balls are negligible because of their long tool life, according to the manufacturer.

In the sizing balls, size tolerances of ±0.000025 in., sphericity tolerances of 0.000010 in. and surface finishes of 1 micro in. are available.

Oxidizing Liquid

A liquid which is claimed to produce oxidation rapidly and with better results than ordinary chemicals, such as Sulphuret, Liver of Sulphur or their substitutes, has been announced by *Hanson-Van Winkle-Munning Co.*, Matawan, N. J.

By adding ¼ fluid oz. of the concentrated oxidizing liquid to each gallon of water, an oxidizing solution can be made for copper, bronze and silver. Solutions can be used hot or cold, but faster operation is obtained when they are hot.

Flameless Electric Torch

A heavy duty Thermal-Jet flameless electric torch which utilizes the radiant electric heat principle has been developed by *Kinetic Products Corp.*, 31 S. 18th St., Philadelphia 3.

Penetrating radiant heat projected by the Thermal Jet will reduce layers of paint, enamel or varnish to a dry, flaky ash which can be removed in one stroke as fast as a professional painter can use a scraper, according to the manufacturer. It is further stated that paint can be removed without disturbing undercoat, filler or caulking. The Thermal-Jet is used like a blow torch but does not burn or scorch the surface, permitting it to be used on canvas-covered surfaces or canoes as well as on metal or wood.

Some of the other uses claimed for the electric torch are setting plaster, tile and marble, melting "dope" from wiring in generator and motor repair shops, spot heating in chemical, industrial and food processing, and annealing light metals.

Paint Stripper Compound

Strip-Aid, a compound which is added in small quantities to alkaline-type paint strippers to speed their action, has been developed by *Klem Chemicals, Inc.*, 14401 Lawson Ave., Dearborn, Mich.

Used with one part Strip-Aid to ten

VISIT KENNAMETAL SPACE 808 ASM SHOW—SEE KENTANIUM

✓ Resists Thermal Shock
✓ Withstands Oxidation
✓ Retains Great Strength
at
HIGH TEMPERATURES

Kentanium greatly widens the scope of engineering design where conditions of intermittent or continuous high temperatures in oxidizing atmospheres are combined with abrasion, and compressive or tensile loads.

This new heat-resistant material is made in several different compositions, each having a specific combination of properties that meet a particular operating condition. The range of these properties is suggested in the table at the right. The proper composition for a specific application is determined by analysis of the conditions under which it will be used.

Kentanium compositions are composed mainly of titanium carbide with other refractory carbides, and an auxiliary metal. They provide higher strength and resistance to oxidation than cast alloys at 1800° F. and above; and greater thermal shock resistance than ceramics.

Our engineers are at your service to help you apply Kentanium to your needs.

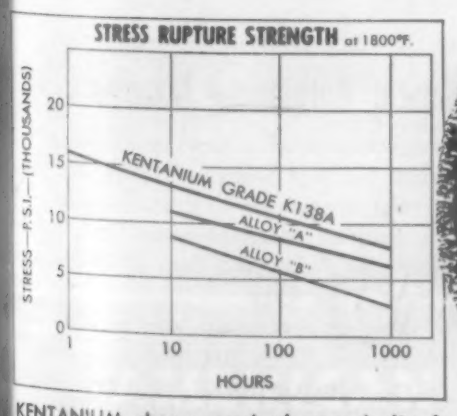
Typical useful applications of Kentanium include: Elements of aircraft propulsion units; hot spinning tools; bushing and shear for hot rod; thermocouple protection tubes; hot extrusion dies; furnace parts; balls for hot Brinell testing; anvils for spot welding; and many others.

Characteristics

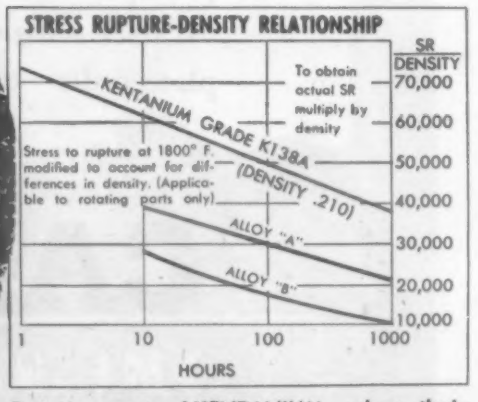
Property		Range
Specific Gravity GMS/cc		5.4—6.0
Thermal Conductivity cal/sec/°C./cm		.075—.085
Electrical Conductivity % of Copper Standard		1.9—5.0
Coeff. of Thermal Expansion x10-⁶/°F. up to 1200°F.		4.5—5.0
Rockwell A Hardness		87.5—93.0
Modulus of Rupture 1000 psi	Room Temp.	112—190
	1800°F.	Approx. 100
Young's Mod. of Elasticity 1,000,000 psi		51.2—57.3
Compressive Strength 1000 psi		Approx. 550

KENNAMETAL®
SUPERIOR CEMENTED CARBIDES
KENNAMETAL Inc., LATROBE, PA.

KENTANIUM
Remarkable New Heat-Resistant Titanium Alloy

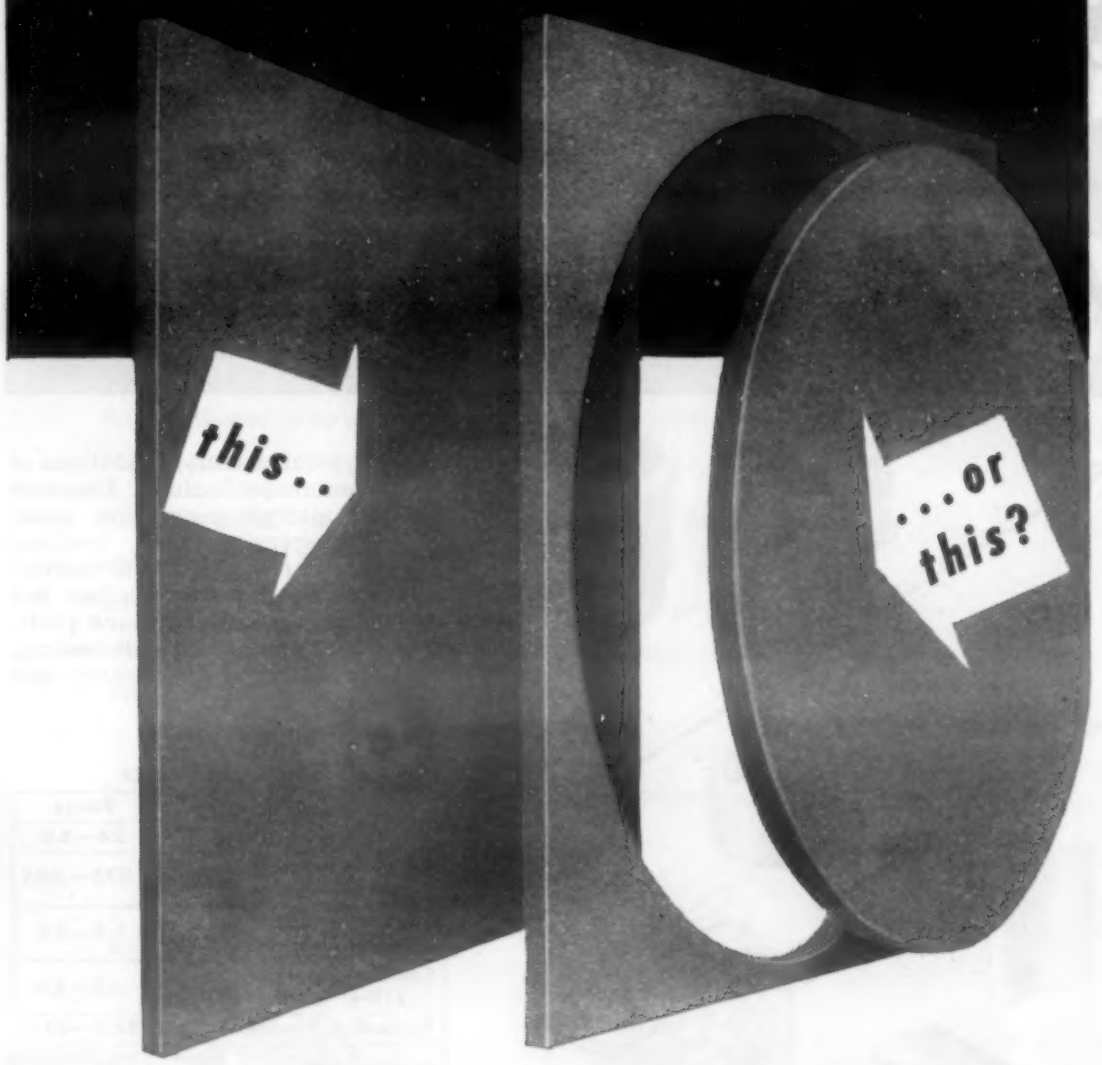


KENTANIUM shows marked superiority in stress rupture characteristics over two commonly-used blade alloys.



Rotating parts of KENTANIUM, when their lower density is considered, have at least 100 times the service life of alloys.

How do you want your
STAINLESS STEEL PLATE?
IN ONE LARGE PIECE
OR SHALL WE CUT IT TO PATTERN?



- G. O. Carlson, Inc. carries at all times a substantial stock of stainless steel plates in many analyses, sizes, and thicknesses to anticipate your requirements.

Many users prefer to purchase full plates from G. O. Carlson, Inc.; many others depend on our exceptional specialized cutting and rough machining facilities for the production of rings, diameters, and pattern cut shapes.

Either way, you will find G. O. Carlson, Inc. your sure source for chemical quality stainless steel plates, delivered promptly—to your precise requirements.

Check with G. O. Carlson, Inc. on your next stainless plate order—ours is an unduplicated specialized service.

G. O. CARLSON, INC.

Stainless Steels Exclusively

200 Marshalton Road, Thorndale, Pa.

PLATES • FORGINGS • BILLETS • BARS • SHEETS (No. 1 Finish)

District Sales Offices and Warehouse Distributors in Principal Cities

New Materials and Equipment

parts commercial stripper (by weight), the compound is claimed to have the following advantages:

(1) The concentration of alkaline strippers required averages 40% less when Strip-Aid is used.

(2) Tank immersion time saved averages 50% and is often cut to one-eighth the time normally required.

(3) Strip-Aid completely breaks the bond between finish and metal surface. It leaves no decomposed paint and eliminates need of additional hand or mechanical cleaning operations.

(4) It is non-inflammable, non-toxic, and does not harm hands or clothing.

Cleaning Shot

A new copper cleaning shot, designed specially for the nonferrous trade, has been developed by *Metals Disintegrating Co., Inc.*, 1170 Arthur Blvd., Elizabeth, N. J.

Called Harrison L/D copper cleaning shot, this product cleans all types of nonferrous castings and pieces by the force of its impact but, according to the manufacturer, does not imbed itself. This makes it possible to obtain the fine finish which results from "working" the surface of the casting without cutting it.

For use in either an air- or wheel-type machine, the shot is made from high grade copper wire in the form of cylinders, the length of each being equal to its diameter. During operation, the cylinders round up to form spheres.

Although the purchase price of Harrison L/D copper cleaning shot is higher than that of steel shot or grit, the manufacturer claims that, in terms of final cost per pound of castings processed, its cost is very low. This is said to result from the small amount of abrasive required in addition to the shot and the reduction of casting rejects ordinarily due to imbedded steel shot.

Automatic Burnishing Machine

Announcement of a new development in equipment for wet ball burnishing and polishing—the completely automatic Tumb-L-Dur burnishing machine—has been made by *Lupomatic Industries, Inc.*, 4510 Bullard Ave., New York City.

The most important feature of this new machine is said to be the molded Tumb-L-Dur barrel, which will not warp and can be kept out of water when not in use. Wooden barrels tested under the same conditions encountered by the Tumb-L-Dur barrel wore

Is YOUR Supplier of Zinc Die Castings On This List?

Only these Companies Are Licensed to Use the Quality Certification Seal....

A & A Die Cast and Plastic Molds Co., West Los Angeles, Calif.
The Accurate Die Casting Co., Cleveland, Ohio
Advance Pressure Castings, Inc., Brooklyn, N. Y.
Advance Tool & Die Casting Co., Milwaukee, Wis.

Badger Die Casting Co., Milwaukee, Wis.

Central Die Casting & Mfg. Co., Inc., Chicago, Ill.
Cleveland Hardware & Forging Co., Cleveland, Ohio
Congress Drives Division, Tann Corp., Detroit, Mich.
Continental Die Casting Corp., Detroit, Mich.
Division of F. L. Jacobs Co.
Crown City Die Casting Co., Pasadena, Calif.

Doehler-Jarvis Corp., Pottstown, Penna.
Doehler-Jarvis Corp., Toledo, Ohio
Doehler-Jarvis Corp., Chicago, Ill.
Dollin Corporation, Irvington, N. J.
Du-Wel Metal Products, Inc., Bangor, Mich.

Fanarc Manufacturing Co., Inc., Whittier, Calif.
Federal Die Casting Co., Chicago, Ill.

Glenvale Products Corporation, Detroit, Mich.
Globe Imperial Corporation, Rockford, Ill.
C. M. Grey Mfg. Co., East Orange, N. J.

Heick Die Casting Corporation, Chicago, Ill.
Hilfinger Corporation, Toledo, Ohio
The Hoover Company, North Canton, Ohio

Kamin Die Casting & Mfg. Co., Chicago, Ill.
Kiowa Corporation, Marshalltown, Iowa
Paul Krone Die Casting Co., Chicago, Ill.

Madison-Kipp Corporation, Madison, Wis.
Milwaukee Die Casting Co., Milwaukee, Wis.
Modern Die Casting Corp., Chicago, Ill.
Monarch Aluminum Mfg. Co., Cleveland, Ohio
Mt. Vernon Die Casting Corp., Mt. Vernon, N. Y.

New Products Corp., Benton Harbor, Mich.

Paragon Die Casting Co., Chicago, Ill.
Parker White Metal Co., Erie, Penna.
Precision Castings Co., Inc., Syracuse, N. Y.
Precision Castings Co., Inc., Cleveland, Ohio
Precision Castings Co., Inc., Reed Metal Crafts Division, Chicago, Ill.
Pressure Castings, Inc., Cleveland, Ohio

Racine Die Casting Co., Racine, Wis.

St. Louis Die Casting Corp., St. Louis, Mo.
Schultz Die Casting Co., Toledo, Ohio
Sterling Die Casting Co., Inc., Brooklyn, N. Y.
Stewart Die Casting Div, of Stewart Warner Corp., Bridgeport, Conn.
Stewart Die Casting Division of Stewart Warner Corp., Chicago, Ill.
Stroh Die Moulded Casting Co., Milwaukee, Wis.
Superior Die Casting Co., The, Cleveland, O.

The Tool-Die Engineering Co., Cleveland, Ohio
Twin City Die Casting Co., Minneapolis, Minn.

Union Die Casting Co., Ltd., Los Angeles, Calif.
Universal Die Casting Co., Los Angeles, Calif.

Wells Die Casting Co., San Francisco, Calif.
Western Die Casting Co., Emeryville, Calif.

The die casters whose names appear here are licensees of The Certified Zinc Alloy Plan. As such their sampled die castings prove on analysis to be of 'on grade' alloy meeting ASTM specifications.

When you buy from any of these die casters you are sure of obtaining zinc die castings manufactured in a plant maintaining proper alloy control.

(A bulletin describing the Certified Zinc Alloy Plan and explaining what it means to the buyer is available on request. Send for a copy.)

AMERICAN DIE CASTING INSTITUTE, INC.
366 MADISON AVENUE NEW YORK 17, N. Y.
D C I

What materials would you choose?

1. CHLORINE CELL COVER: Previous cement covers deteriorated rapidly, gave rise to contamination in vorce cell, with consequent increased current and maintenance costs. Now made of material that combines high strength with superior electrical and chemical resistance to give longer life, cleaner product. What material?

2. BATTERY VENT CAP: Permits gases to escape from auto battery without letting acids out. Must be low in cost, resistant to acids. Should permit high molding rates, easy assembly and cementing of two halves. What material would you try first?

Answers: No. 1—Ace Molded Hard Rubber greatly increased life of vorce cell covers, may do same for your designs. No. 2—Try Ace Parsan (polystyrene) *first* for any job similar to this Ace-molded vent cap.

Yes, sometimes it's hard rubber, sometimes one of the other plastics that's best. Ace, with many hard rubber and plastic compounds to choose from, is fully equipped to supply whatever you need.

Ask for ACE Handbook

ACE
Since 1851

HARD RUBBER and PLASTICS

AMERICAN HARD RUBBER COMPANY

11 MERCER STREET • NEW YORK 13, N. Y.

New Materials and Equipment

out in 3½ to 4 weeks, according to th manufacturer, while Tumb-L-Dur barrels i use for 1½ years show no sign of deteri oration.

Since there are no bolts or screws insid of the burnishing machine itself, work be ing burnished or finished will not b marred by coming in contact with projec tions. In removing the work, a perforate tray is placed in the machine which is the given a half turn. The balls automatically separate from the work and the finished parts come out of the machine in less tha a minute.

Ball Mill Grinding Medium

A new non-metallic ball mill grinding medium called Borundum has been de veloped by the *U. S. Stoneware Co.*, 530 East Talmadge Ave., Akron, Ohio.

Heavy, hard and tough, and resembling synthetic sapphire in composition, Borun dum Grinding Media weigh from 75 t

Borundum Grinding Media weigh from 7 to 80% more and are up to 50% hard than conventional media, such as porcelain balls or flint pebbles.

80% more and are up to 50% harder tha conventional media, such as porcelain ball or flint pebbles. Borundum's dense, non absorbent body and its white, smooth, easily washed surface permit its use interchange ably in grinding various materials without danger of inter-material contamination.

Metal Stripper

Enthone, Inc., Dept MA, 442 Elm St New Haven, Conn., has announced the de velopment of a new product for the rapid stripping of nickel, tin, lead and chromium from copper, brass and other copper alloys without attack upon the base metal.

In a process involving no current, the work to be stripped is immersed in an acid

meet the "Sandman"

Yep! . . . there really is a sandman! Sivyer's sandman, however, is a symbol of vigilance . . . for he uses special equipment and a broad practical knowledge to test sand for specific moulding jobs. Dimensional accuracy, the finish, even the internal flawlessness of a casting may depend on his tests for proper bond, grain size, and permeability. The unique skill of our sand laboratories is another Sivyer service that insures casting quality and integrity for you.

wake up to better steel castings

A letter or a wire will get you prompt action and details on any problem or service involving high alloy and specification steel castings. Get acquainted with the famous Sivyer (S) for better castings.

SIVYER

SPECIALISTS IN HIGH ALLOY AND SPECIFICATION STEEL CASTINGS

SIVYER STEEL CASTING COMPANY • MILWAUKEE (S) CHICAGO (S)

for

UNIFORMITY

use our

Sponge Iron Powder

in

Powder Metallurgy Fabrication

& Other Metallurgical Purposes

●

... Call in your ...

Compacted Parts Fabricator

for Design Consultation

●

EKSTRAND & THOLAND, INC.
441 LEXINGTON AVENUE
NEW YORK 17, NEW YORK

Sellers of Hoeganaes Sponge Iron Powder

New Materials and Equipment

solution containing Metal Stripper N-1 Stripping rates as high as 0.006 in. hr. of nickel are obtained, according to manufacturer. The process is said to be for the removal of nickel from bulk pla work as well as heavier plated objects, s as percolators, flashlights, plumbing go and other items made of copper.

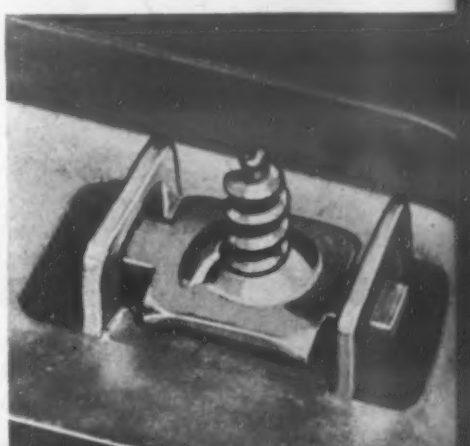
Enthone Metal Stripper N-165 is s plied as a neutral powder, safe to han and easy to use.

●

Welding & Joining

Cage Nut

A new cage nut, called P-1079, wh does not require a separate cage has b developed by *Prestole Corp.*, 1339 Mi St., Toledo 5. Locked in place by droppi it over two pre-punched loops that can



The new Prestole cage nut makes an in pensive "floating" cage nut.

pulled up with ordinary pliers, the c nut is claimed to save metal and to elim nate spot welding.

Made of spring or mild steel, dependi on the torque requirements, the nut is pr duced to fit regular sizes of sheet me screws.

Nut Driving Machine

An increasingly urgent need for mo efficient and rapid assembly of nuts to ke pace with modern production methods h led to the development of an automatic n

Twice as fast
FROM ROCKRITE TUBING

You can often *double* output and cut machining costs *in half* by using close-tolerance Rockrite Tubing for cylindrical and ring-shaped parts. Take ball-bearing raceways, produced from 52100 analysis tubing, for example . . .

They are now being turned out twice as fast from Rockrite Tubing as from ordinary tubing. Quick reaming replaces slow boring. Outside finishing is faster because Rockrite Tubing is sized to much closer tolerances than tubing sized by other methods. Additional stations can frequently be released so that two parts can be machined at once with a double cut-off. Tool costs go down.

DO YOU KNOW the 3 requirements essential for tube accuracy? Read about them in new bulletin being prepared that tells how and why close-tolerance Rockrite Tubing can save you money.

ROCKRITE TUBING

Rockrite Saves More Than Any Other Tubing

- **Higher cutting speeds**
- **Tools last longer between grinds**
- **Work-surface finishes are better**
- **Stations on automatics are often released for additional operations**
- **Extra-long pieces available—less down-time for magazine stocking and fewer scrap ends**
- **Closer tolerances often eliminate necessity for machining on outside or inside**

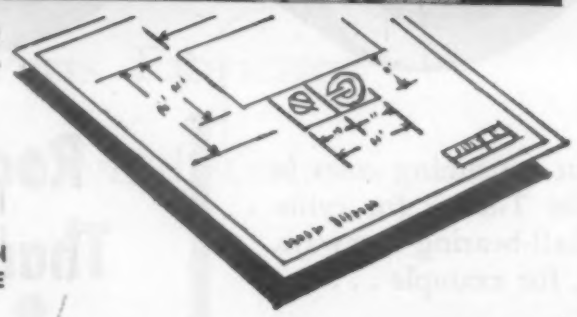
TR 115

TUBE REDUCING CORPORATION · WALLINGTON, NEW JERSEY

★ TOP PERFORMANCE WITH AJAX TAMA-WYATT

INDUCTION FURNACES for Aluminum Alloys

Ajax Induction Holding Furnace at Mid-Western Die Casting Co., Chicago, Illinois.



★ BETTER PRODUCTION THROUGH TOP PERFORMANCE IS THE AJAX RECORD

Ajax-Tama-Wyatt induction furnaces are used in the United States and abroad for melting and holding aluminum alloys in die casting, permanent mold, and sand foundries.

No flux or mechanical stirring is necessary. The metal is in constant gentle circulation assuring complete blending of alloys, and a uniform temperature throughout the metal.

Electric energy costs less than fuel and avoids danger of overheating. Completely automatic temperature controls hold metal to within 5°F., at the lowest possible temperature for perfect casting. With an Ajax the yield for perfect castings is exceptionally high.

There are no fumes and operation is practically noiseless. Shops are cooler, more comfortable — manpower efficiency is increased. Shop space is increased, for an Ajax Holding Furnace takes an average of 30 to 40 percent less floor space than any other furnace.

The Ajax companies have been pioneers in induction melting of metals since the first World War. To date they have installed more than 400,000 KW. of furnace capacity in the United States alone. This is the background of experience behind every Ajax installation.

AJAX ENGINEERING CORPORATION • Trenton 7, New Jersey

AJAX TAMA-WYATT INDUCTION MELTING FURNACE

Associate Companies: AJAX METAL COMPANY, Non-Ferrous Ingot Metals and Alloys for Foundry Use
AJAX ELECTROTHERMIC CORP., Ajax-Northrup High Frequency Induction Furnaces
AJAX ELECTRIC CO., INC., The Ajax-Hultgren Electric Salt Bath Furnace
AJAX ELECTRIC FURNACE CORP., Ajax-Wyatt Induction Furnaces for Melting

New Materials and Equipment

driving machine by *Detroit Power Screwdriver Co.*, 2801 W. Fort St., Detroit.

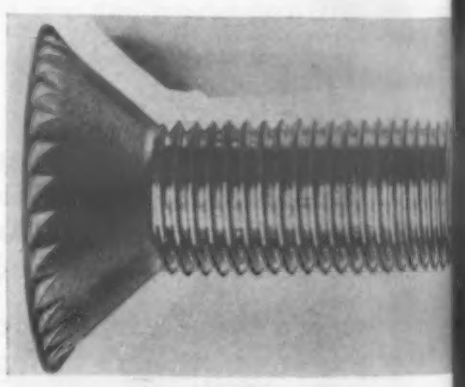
Driving nuts semi-automatically or automatically, the machine entirely eliminates the manual handling of nuts at any time except to load the rotary barrel-type hopper periodically with a fresh supply of nuts. The hopper keeps the machine continually charged with an ample supply of nuts, and feeds them in a prepositioned manner to the driving spindle, thus making handling by the operator completely unnecessary.

The machine will handle nuts ranging in size from 5/16 in. min. to 11/16 in. max. across flats and including special varieties such as jam, castillated and locks nuts.

"Washer-Less" Screw

Designed to eliminate the time-wasting step of adding a washer to a screw in assembly operations, a new "washer-less" screw is being produced by *Russell, Burdsall & Ward Bolt & Nut Co.*, Port Chester, N. Y.

Unusual in design, the Spin-Lock screw has ratchet-like teeth on the underside of the head and consists of one piece, allowing it to be hopper-fed.



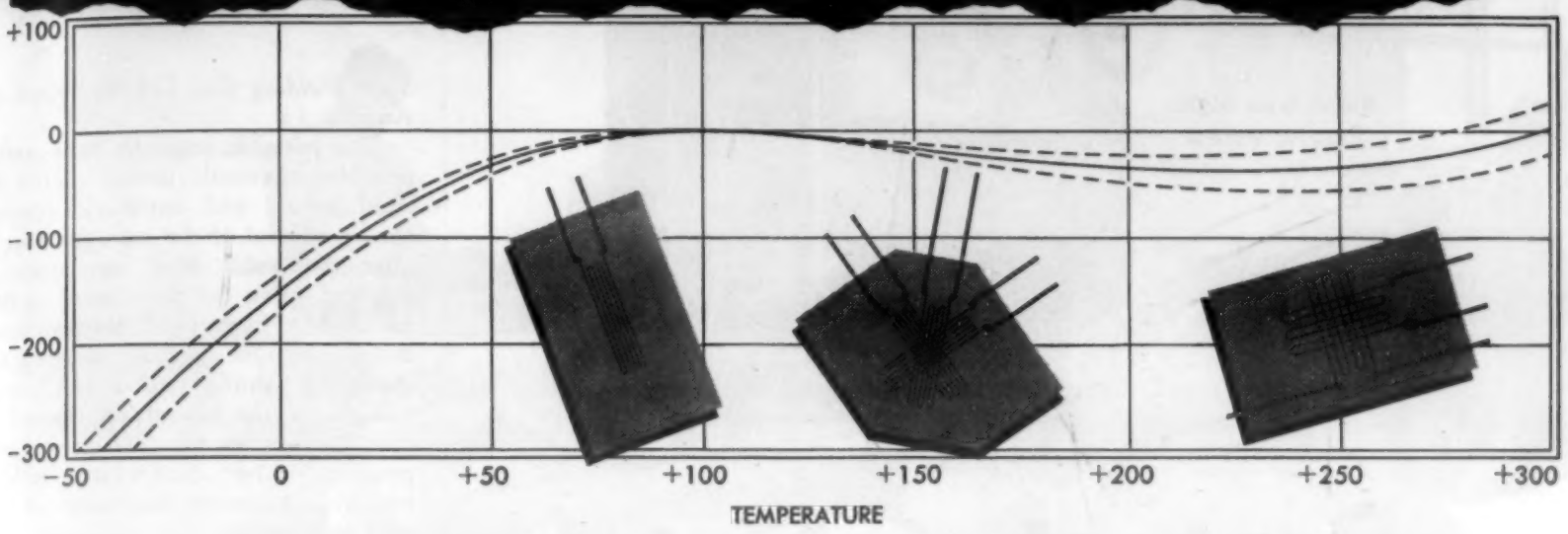
This new Spin-Lock screw eliminates the need for a washer in assembly operations

Other advantages claimed for the Spin-Lock screw by the manufacturer are that (1) cuts inventory and purchasing costs, (2) has positive locking power, as there are no parts to cant or fall off; (3) fastens neater (flush with surface); and (4) is safer (no protrusion to catch fingers or clothes).

Stud Welding Control Unit

Designed for the shielded (inert gas) stud welding of such metals as aluminum and stainless steel, a new welding control unit is being manufactured by the *Shield*

WHEN RAPID TEMPERATURE CHANGES COMPLICATE STRESS TESTS HERE'S YOUR CURE



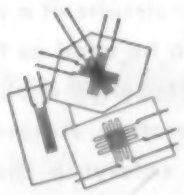
THE *NEW* BALDWIN SR-4®

SELF-COMPENSATING STRAIN GAGE

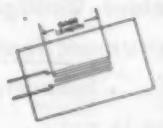
rther broadening the field of usefulness of Baldwin -4 Strain Gages, this newest addition to the line minates another unknown in stress-strain investi- tions by providing built-in compensation for rapid riations in temperature occurring during the test.

One obvious use is in aircraft testing, where rapid changes in plane elevation bring corresponding rapid changes in temperature. The effect is to introduce known errors in the strain gage readings even ough conventional dummy gages are employed.

Previously, compensation for temperature changes invariably called for the use of a dummy gage. The new self-compensating gage makes this duplication unnecessary and minimizes errors that might be introduced by lead or lag in the dummy gage temperature change.



The new Self-Compensating gage will be manufactured in rosette, double-element, and single-element form. Temporarily, only the single-element will be carried in stock; others are available on special order.



Gage lengths available are 7/8″; 13/16″; 3/8″; and 1/4″. Copper-nickel wire is utilized in the element. Degree of compensation is suggested by the chart above.

A data sheet giving detailed dimensions, packaging information, and other details will be sent on request.

The Baldwin Locomotive Works, Philadelphia 42, Pa., U. S. A. Offices: Chicago, Cleveland, Houston, New York, Philadelphia, Pittsburgh, San Francisco, St. Louis, Washington. In Canada: Peacock Bros., Ltd., Montreal, Quebec.

BLW THE BALDWIN GROUP

BALDWIN

TESTING HEADQUARTERS

Heating Safety

Alnor Type 5200 Pyrotac excess temperature cut-off.

Protects

Your Investment

The Alnor Pyrotac excess temperature cut-off offers you low-cost, automatic protection against damage due to excessive temperatures . . . safeguards your investment in heating equipment and materials in process.

Simple in operation, the Pyrotac constantly indicates temperature of the heater equipment and stands ready to sound an alarm and/or shut down heater circuits at a pre-set maximum safe temperature. It may also be used as the only control instrument on a process that requires a complete shutdown upon reaching a final temperature. Automatic thermocouple break protection assures safety in the event that thermocouples or extension wires should break or burn out.

Small size, simple wiring makes it easy to install the Pyrotac on existing control panels. Available in scale ranges from 0°-600°F. to 0°-3000°F. and equivalent Centigrade ranges.

Here is another Alnor quality instrument featuring Alnico magnet, double air gap movement . . . laboratory precision and husky construction; yet the price is only . . .

$85 ***far lower than for ordinary instruments of this type***

Ask your Alnor Representative for complete details or write for bulletin that contains full description and wiring diagrams that show actual applications.

Alnor

Illinois Testing Laboratories, Inc.
Room 522, 420 N. La Salle St., Chicago 10, Illinois

PRECISION INSTRUMENTS FOR EVERY INDUSTRY

New Materials and Equipment

Stud Welding Co., 124 W. Fourth St., L Angeles 13.

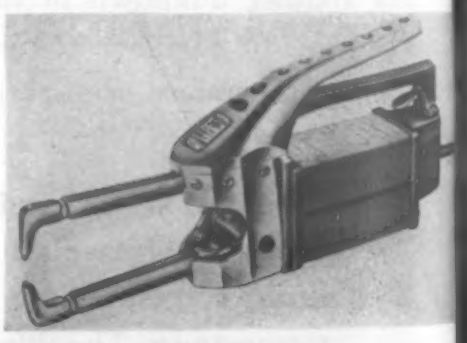
This portable, ruggedly built control u provides electronic timing control for s weld period and automatic (pneumat timing control of the inert gas prior to s after the weld. Also incorporated are solenoid valve for the control of the in gas and a high-speed magnetic-type co tactor which is specially designed for fr quent short timing periods and heavy loa

Some of the advantages claimed by t manufacturer for the control unit are: (1 provides higher quality stud welds; (2 improves corrosion resistance of stainl steel stud welds; (3) eliminates the ne for ceramic ferrules in many instances; a (4) saves inert gas consumption.

Portable Spot Welder

A new portable spot welder, known a the Zip, has been introduced by *Mid-Stat Welder Mfg. Co.*, 6025 S. Ashland Ave Chicago 36.

Patented features of the Zip include fixed top tong and newly-designed adju



This well balanced spot welder, with cent of gravity at the carrying point, can be op erated with one hand.

able curved tips, affording greater ease o handling and operation. A well balanc unit, the welder is claimed to have it center of gravity at the carrying poin allowing it to be operated with only on hand.

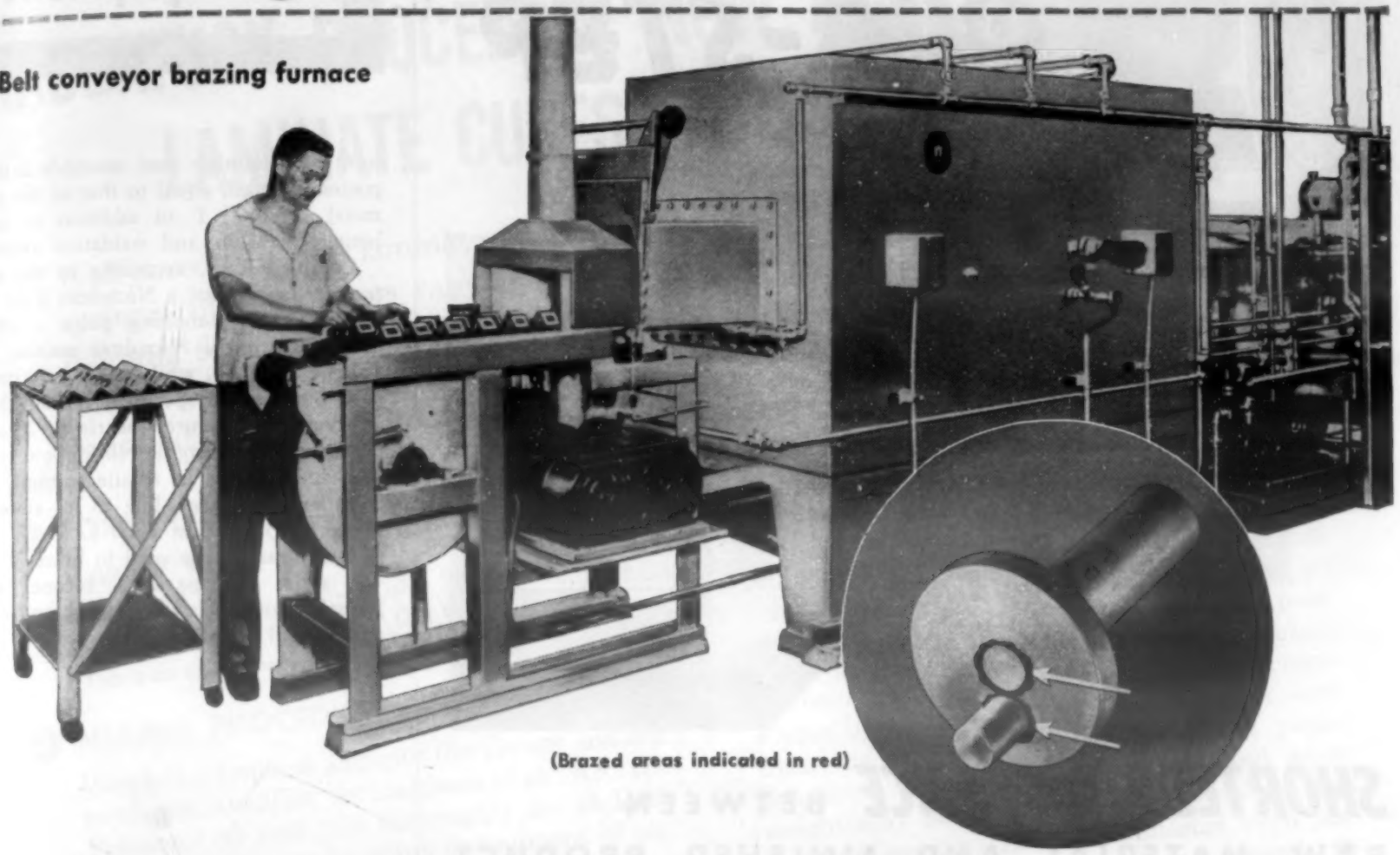
The Zip is completely portable, weigh 23 lb. and welds mild steel, stainless, ga vanized iron, terne plate, and magnesium up to ⅛-in. combined thickness of mete

Brazing Alloy

A new heat and corrosion resistant allo for brazing stainless steels has been de veloped by *Wall Colmonoy Corp.*, 1934 John R St., Detroit 3. When brazed wit this new material, called Nicrobraz, the

YOU CAN BE **SURE**.. IF IT'S

Westinghouse



Belt conveyor brazing furnace

(Brazed areas indicated in red)

$1,120 SAVED

every 8 working hours with Westinghouse Brazing

Four cents per unit! $1,120 every eight hours. That's what one manufacturer saved when he switched from machining to Westinghouse brazing. With production of 3,500 units per hour, each furnace produced these startling savings.

Why spend dollars? Braze it for pennies with Westinghouse equipment. The Westinghouse brazing furnace is only one of a wide variety of furnaces—both gas-fired and electric—produced by Westinghouse.

For either gas-fired or electric operation, Westinghouse can make thorough, impartial recommendations for the type of equipment needed to handle your heat-treating problem most economically. Get all the facts today. Call your nearest Westinghouse office or write Westinghouse Electric Corporation, 186 Mercer Street, Meadville, Pennsylvania. J-10347

Therm-a-neering. A HEAT AND METALLURGICAL SERVICE THAT OFFERS WITHOUT OBLIGATION:

ENGINEERS—Thermal, design and metallurgical engineers to help you study your heat-treating problems with a view toward recommending specific heat-treating furnaces and atmospheres.

RESEARCH—A well-equipped metallurgical laboratory in which to run test samples to demonstrate the finish, hardness, and metallurgical results that can be expected on a production basis.

PRODUCTION—A modern plant devoted entirely to industrial heating.

EXPERIENCE—Manufacturers of a wide variety of furnaces—both gas and electric—and protective atmosphere generators.

Westinghouse

GAS AND ELECTRIC

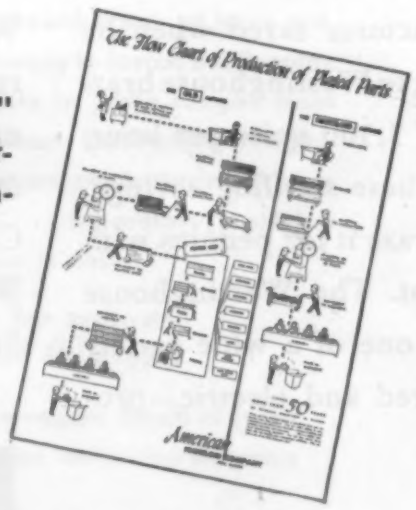
Furnaces

SHORTEST DISTANCE BETWEEN
RAW MATERIAL AND FINISHED PRODUCT

Nickeloid *Pre-finished* Metals eliminate many costly operations — cleaning, plating, polishing — and in addition provide lustrous new beauty. You simply *fabricate*, then *assemble!* And those *two steps* take you to lower production costs, *plus* greater product beauty.

Nickeloid Pre-finished Metals are available in sheets or coils, in wide range of gauges, and tempers, plated one or two sides, bright or satin finishes of Chromium, Nickel, Brass or Copper, plated to base metals such as Steel, Zinc, Brass, Copper or Aluminum.

Write for new "Flow-Chart" showing how Nickeloid Pre-finished Metals eliminate costly production operations.



NICKELOID METALS (Pre-Plated)
NICKEL · CHROMIUM · BRASS · COPPER
Electro-plated TO ALL COMMON Base METALS
ALSO LACQUERED COLORS
SHEETS AND COILS
OLDEST AND LARGEST PRODUCERS OF PRE-PLATED METALS

Established 1898
AMERICAN NICKELOID COMPANY
PERU 6, ILLINOIS

New Materials and Equipment

joint of a stainless steel assembly is said to possess strength equal to that of the parent metal at 2000 F in addition to having better corrosion and oxidation resistance.

Complete tests, according to the manufacturer, show that a Nicrobraz joint has a much higher re-melting point (2600 F) than the original Nicrobraz melting point (about 1850 F), while the tensile strength of a butt brazed specimen is 120,000 psi. at room temperature—nearly 90% of the parent metal strength. No signs of oxidation and no loss in tensile strength result from exposing the alloy to an air atmosphere for 510 hr. at 1600 F.

Nicrobraz can be used to braze 300 and 400 series stainless steel, Inconel, S-590, Monel, alloy steels, tool steels, and carbon and special stainless steels.

Forming & Machining

New Swager

A swaging machine which features newly developed special dies and which is claimed to swage harder and tougher steels in length-to-diameter ratios above previously accepted standards has been marketed by *Fenn Mfg. Co.*, 1841 Broad St., Hartford, Conn.

One of the advantages claimed for this swager is the saving in material that it affects. The spindles it produces were formerly turned out on automatic lathes which turned blanks 10 in. long, producing three different tapers, including the Morse taper on the shank. They were then finish-ground to specified dimensions.

With the new Fenn swager, however, material requirements are said to be cut in half. Blanks only 4½ in. long are needed, the material being lengthened by the swager as the tapering operations are performed. The finished length is 9 in.

Among the benefits said to be obtained by swaging the spindle and similar products are:

1. The physical and metallurgical characteristics of the material are improved, with a denser structure being obtained. In this respect, swaging is similar to cold forging.

POLYESTER REPORTER

NAUGATUCK PROCEDURE NOW MAKES POSSIBLE LAMINATE CURES WITHOUT OVENS

Well-cured polyester laminates, without external heat, are possible with promoted systems in thicknesses ranging from 50/1000″ to 1″. In addition, the time required to accomplish this can be greatly reduced by using simple paper insulation to utilize the exothermic heat evolved. Illustrative data and a suggested formulation are as follows:

❶ FORMULA

VIBRIN® 112	100 parts
Luperco ATC	3 "
Promoter #3*	0.3 "

This is an amber-colored liquid.

❷ MIXING PROCEDURE

Weigh the Luperco ATC into the VIBRIN and stir to clarity, avoiding the inclusion of air. Add the Promoter #3 and mix thoroughly for at least one minute; again avoiding entrapment of air.

CAUTION: The pot life of the above formulation is limited to approximately 30 minutes, so lamination must be planned accordingly. If it is desired to either lengthen or shorten the cycle, variations by 0.1 part of Promoter #3 are recommended.

❸ HANDLING PROCEDURE

Place a layer of cellophane on a smooth working base. Pour and spread a portion of the catalyzed-promoted VIBRIN evenly over this. Lay on first layer. Pour on another portion of resin. Lay on next layer, and so on, to desired thickness. Cover with cellophane, and squeegee to obtain uniform saturation throughout the structure. Finish by squeegeeing all air and excess resin from the laminate. Apply ¼″ porous paper insulation if desired. (Metal plate and some weight may be used to achieve maximum surface uniformity.) After 90 minutes even the thinnest laminate will be strong enough to handle and will develop full cure according to schedule in "4" (below).

❹ EFFECT OF INSULATION ON CURE TIME

Cure Time	Recommended Thickness Range for Good Cure (L110) Insulated	No Insulation
2 Hours	.072–.210 inch	.210–1.00 inch
1 Day	.060–.072 "	.165–.210 "
2 Days	.050–.060 "	.130–.165 "

NEW METHODS—NEW MATERIALS AVAILABLE TO YOU

The laminate cure described above typifies the improved methods and materials which our laboratories are constantly developing. These time-saving, cost-saving procedures are now available to you . . . along with 6 standard VIBRIN polyester resin types (including self-extinguishing and water white). And remember, there's always a Naugatuck technician to solve your special problems.

Naugatuck Chemical

DIVISION OF UNITED STATES RUBBER COMPANY
NAUGATUCK, CONNECTICUT

GET IMPORTANT POLYESTER NEWS AS IT HAPPENS

Without charge, we'll send you *regularly* full reports of our new developments in lamination curing, resin types, dyes and application practices. *Just send coupon today.*

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Plastics Division, Dept. C-1, Naugatuck, Connecticut

Please send me regularly, without charge, your full technical reports.

Name.....Title.....

Company.....

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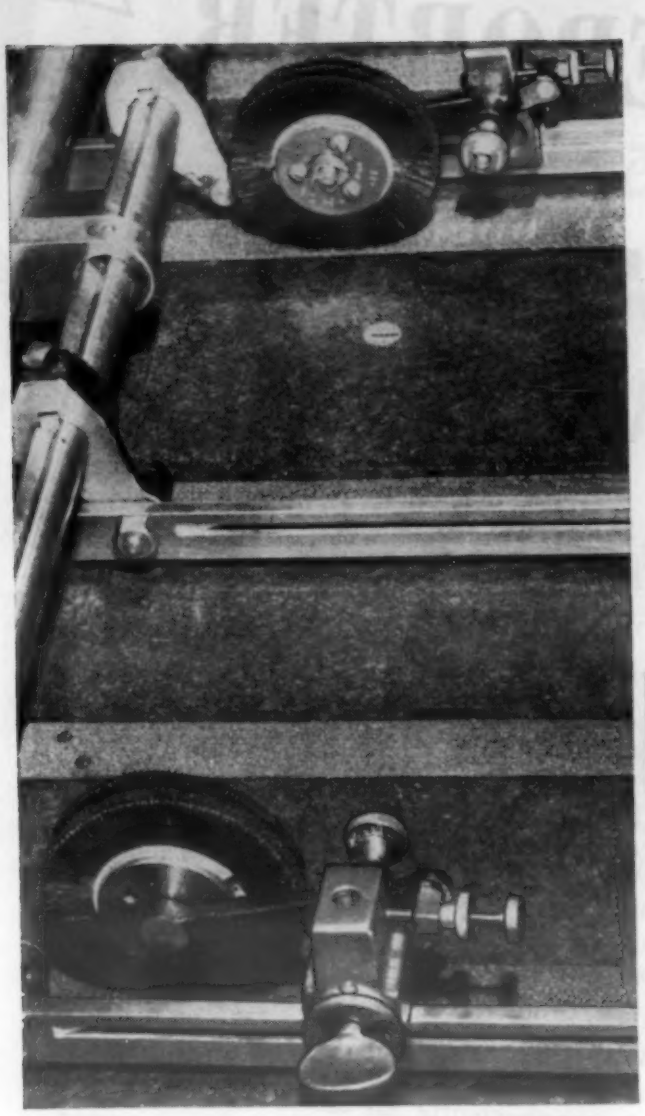
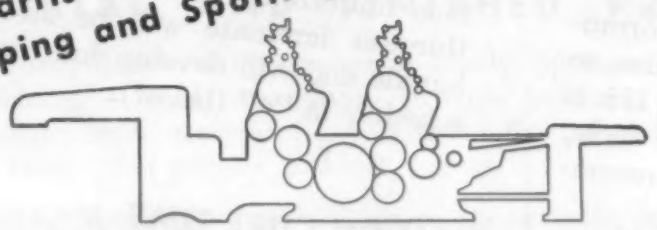
City.....Zone.....State.....

IN CANADA: NAUGATUCK CHEMICALS, DIVISION OF DOMINION RUBBER CO., LTD., ELMIRA, ONTARIO



WHERE "WHOA" PREVENTS WOE

FULLERGRIPT BRUSHES on Harris Offset Presses Keep Paper from Creeping and Spoiling Side Register . . .



In offset printing, unless paper is held in line on the feed table, it creeps back up the table and spoils the side register The Harris-Seybold Company of Cleveland eliminated this risk by installing 2" wheels, made of Fullergript brush strips, to work in conjunction with the moving web tapes underneath the sheet of paper. These brushes hold the sheet of paper against stop fingers while it is being side registered.

Many problems in industry are being licked with Fullergript brushes. They are used on numerous applications besides brushing. For further information, simply write to

DO YOU REQUIRE A SPECIAL MACHINE FOR A BRUSHING OPERATION? You can benefit from our wide experience in designing and building special brushing machines. No obligation to lay your problem before our engineers. Write today.

FULLERGRIPT The FULLER BRUSH CO.

INDUSTRIAL DIVISION, 3636 MAIN ST., HARTFORD 2, CONN.

New Materials and Equipment

2. Alloys can be cold formed, which otherwise have to be hot forged.

3. Swaging imparts a high finish to the material, often eliminating the need for special finishing operations.

4. Less skill is needed to operate a swager than any other machine that can produce an equivalent metal part.

5. Distortion during subsequent heat treating is equal to or less than that resulting from turning.

Bending Machine

A new machine that completely forms a variety of cabinets in one piece and in a single cycle of operations has been developed by *Cyril Bath Co.*, 6901 Machinery Ave., Cleveland 3.

This new machine, known as the Open-Throat, Single-Wing Tangent Bender, produces cabinets with either flat or crowned sides and is readily adapted to making bends of different radii, so that many types of cabinets can be formed on the same machine.

In action, the ram of the bending machine descends rapidly to within 1 in. of the bottom of its full stroke. At this point, latches at both ends of the ram engage levered arms on the bed and pull the ram down with a pressure of more than 17 tons. Flat metal sheets can be blanked, punched, or otherwise formed during this initial movement, and then held steady for the bending wing to move up and form the corner radius, with wrinkle-free flanges.

Many of the benders are already turning out television set housings, refrigerator cases, liners and evaporator shells, and cases for electric ranges, space heaters and other small appliances, at rates up to 400 bends per hour.

Drawing Press

Designed for mass production of heavy gage steel parts, a new 750/500-ton Fastraverse sheet metal drawing press is available from the *Hydraulic Press Mfg. Co.* of Mount Gilead, Ohio.

This all-hydraulic press handles deep drawing, forming and blanking operations on both heavy and light gage stock. For this heavy-duty work, the press is equipped with a 250-ton blankholder and a 200-ton hydraulic die cushion with a 36-in. stroke. It is said that the press will draw and lift out a part 36 in. deep.

Some of the outstanding design features claimed for this press are the adjustable blankholder pressure at each of the four

(Continued on page 126)

it's easy if you know how

As versatile as stainless is, you may find it difficult to apply stainless steel to your job unless you know which stainless analysis you need. That's why Crucible, pioneers in the development of this specialty steel, makes freely available to you an alert metallurgical staff. These engineers and metallurgists can show you which stainless analysis is best suited for your application. And how Crucible Stainless can be applied for maximum satisfaction.

Take full advantage of Crucible's half century of specialty steel leadership — leadership based on a keen devotion to detail . . . on every Industry-posed problem . . . whether the order is in tons or pounds. When you think of stainless . . . call in Crucible. CRUCIBLE STEEL COMPANY OF AMERICA, Chrysler Building, New York 17, N. Y.

CRUCIBLE first name in special purpose steels

STAINLESS STEELS

fifty years of Fine steelmaking

STAINLESS • HIGH SPEED • TOOL • ALLOY • MACHINERY • SPECIAL PURPOSE STEELS

The Furnace Roller is

DURALIZED!

And what is "Duralizing"?

It's a surface treatment given to the casting

1 . . . to make it more resistant to abrasion

2 . . . to make it more resistant to molten metal

3 . . . to minimize "pick up"

This is a treatment we developed in our own laboratory and foundry to meet special conditions for certain furnace operations. Normal high alloy castings would withstand the heat all right but abrasion, erosion and pick up were something else again. The "Duralized" Rolls solved the problem.

While you may not need a high alloy casting calling for the Duralizing treatment, you may have a high alloy casting problem. We'll be glad to study it with you and recommend the alloy and type of casting best for your requirements.

THE DURALOY COMPANY

Office and Plant: Scottdale, Pa. • *Eastern Office:* 12 East 41st Street, New York 17, N. Y.

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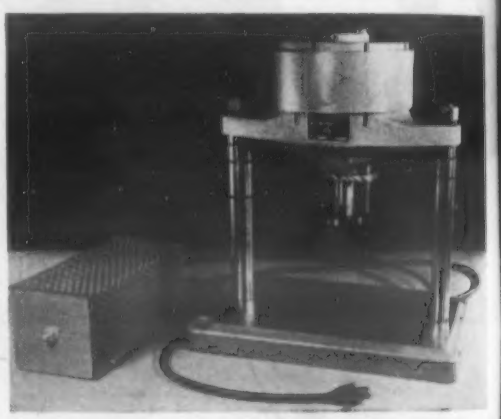
New Materials and Equipment

corners of the slide, rapid advance to work with automatic slowdown as die contacts work, complete automatic press cycle handled by push button controls, and automatic press reversal.

Electric Impact Hammer

A new, heavy duty electric impact hammer is being manufactured by *Black & Webster, Inc.*, 30 Pleasant St., Needham, Mass.

Known as the Electropress, it is claimed not only to deliver an impact up to 6000 lb. (calculated on work done through a distance of 1/64 in.), but to follow through with a "squeeze" or pressure of 2000 lb. at the end of the stroke. Both impact and pressure can be easily controlled with the addition of an impact control which will deliver any desired impact from a light blow to its rated maximum.



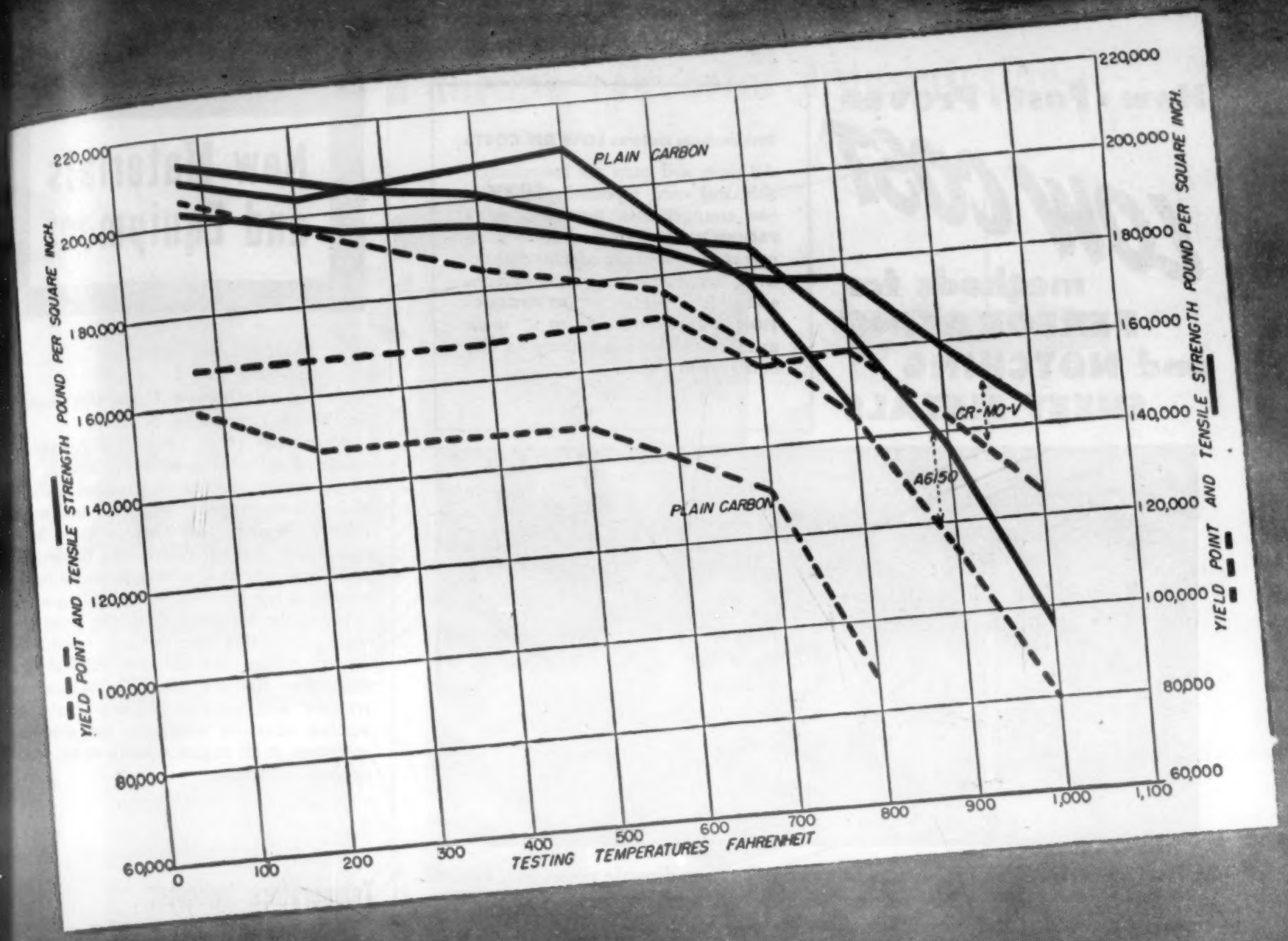
This new electric impact hammer is a versatile performer, rugged, and easy to operate.

The Electropress is all electric, operating from any 115-v. a.c. outlet and employing direct electromagnetic attraction in its operation. Drawing less than 10 amp., and this only during the power stroke, it is said to cost only a few cents a week to operate.

Testing & Control

Abrasion Testing Set

A new, durable, precision-built test instrument designed to evaluate the resistance of surfaces to rubbing abrasion is available



HIGH TEMPERATURE PROPERTIES

of Cr-V and Cr-Mo-V Spring Steels

SPRINGS FOR SERVICE at elevated temperatures require steels which resist softening and lowering of the yield point. Unless hardness and yield strength are stabilized by correct alloy additions to the steel, these properties deteriorate rapidly as the temperature is raised.

The chart above shows the yield point and tensile strength of three types of spring steel at elevated temperatures determined by standard short-time tension tests.

Springs of plain carbon steel are sometimes used at moderately elevated temperatures, although their lower yield values prevent them from giving service as satisfactory as that of the alloy spring steels.

Chromium-vanadium steel springs, such as AISI 6150, give better service at ordinary temperatures because of the higher yield point. In addition, they may be used at operating temperatures up to about 700° or 750° F because they retain high yield point values as the temperature is increased.

Chromium-molybdenum-vanadium steel was especially designed for springs operating at temperatures in excess of 750° F. It can be used for springs operating at temperatures as high as 850° F or even higher under some conditions. At 800° F, the yield point of this steel is still greater than that of plain carbon steel at room temperature.

If you have a problem in spring applications at elevated temperatures, our metallurgical engineers will be glad to help you solve it.

MAKERS OF ALLOYS — VANCORAM BRAND — CHEMICALS AND METALS

VANADIUM CORPORATION OF AMERICA

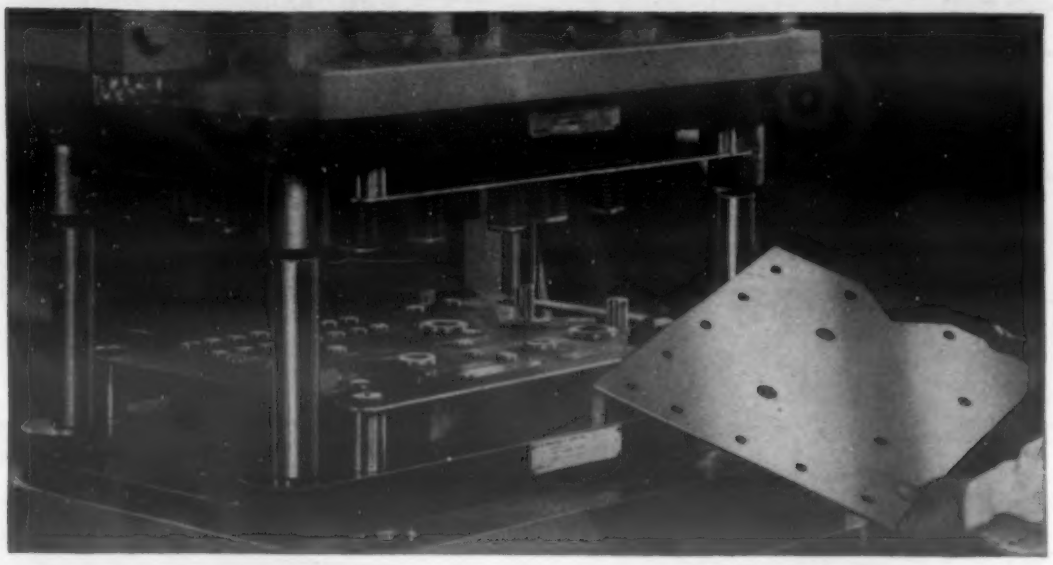
420 LEXINGTON AVENUE, NEW YORK 17, N. Y. • DETROIT • CHICAGO • CLEVELAND • PITTSBURGH

New • Fast • Proven

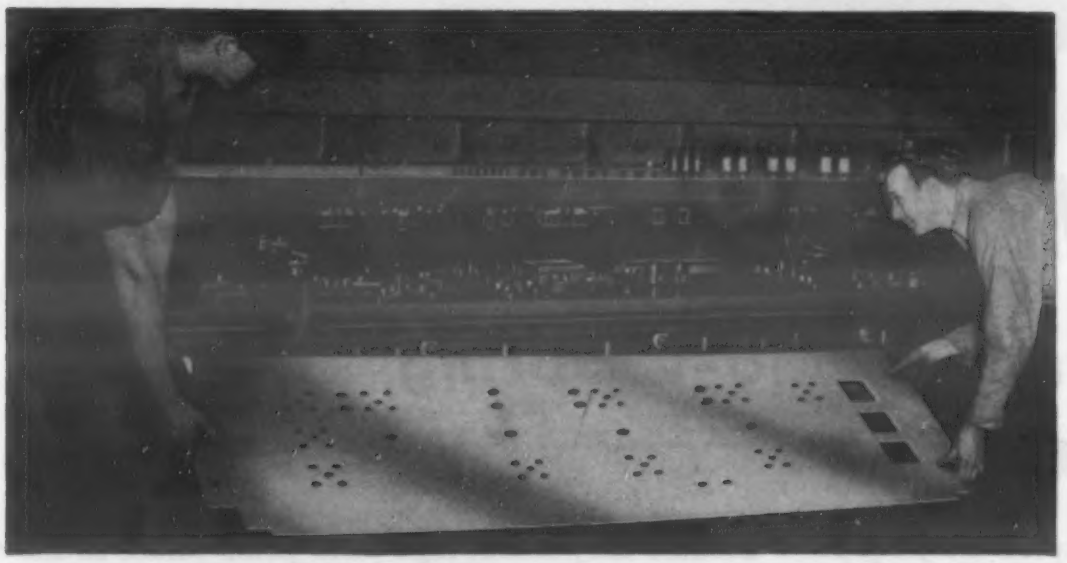
LOW COST methods for PERFORATING and NOTCHING SHEET METALS

Both methods feature: LOW DIE COSTS

All units and parts are interchangeable and used repeatedly in different arrangements. **INCREASE PRESS PRODUCTION**—Down time is minutes as compared to hours for changeover. For precision work in all types and sizes of presses. **START PRODUCTION *at once.*** Pierce up to ¼" thick mild steel. Saving money in the best known plants.



Whistler *MAGNETIC* Dies at work in large inclinable press. Magnetized units hold the retainers. No bolting required. A fast, economical method in making up a punch and die set for short or long runs. All parts re-usable.



Whistler *ADJUSTABLE* Dies on ⅛" steel perforating and notching job, using Tee slotted die set. With Whistler Adjustable Punch and Die units production starts within hours instead of weeks. Last minute job changes made quickly.

Here are the complete details with prices and application illustrations. Send for these catalogs. No obligation.

NAME

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CITY ZONE STATE

S. B. WHISTLER & SONS, Inc.

Adjustable, Magnetic, Custom and Cam Dies for all Industry

756 Military Road, Buffalo 23, N. Y.

New Materials and Equipment

from *Taber Instrument Corp.*, 109 Gounda St., North Tonawanda, N. Y.

Called the Taber Model 140 Abraser, its range of application is said to include tests of painted, lacquered, electroplated surfaces and plastic coated materials, and textile fabrics ranging from sheer silks to heavy upholstery, leather, rubber and linoleum.

Rotary rub wear action provided by the abraser is the result of dual abrading wheels rubbing the specimen from the center outward and from the outside toward the center, causing the abrasion lines to cross each other like the letter "X." The wheels traverse a complete 360-deg. circle, revealing abrasion resistance on the same specimen at all angles relative to the weave or grain direction.

Temperature Indicator

To meet the increasing demand for simple means of indicating high temperatures, *Tempil Corp.*, 132 W. 22 St., New York 11, has developed new Tempilaq ratings which range from 1650 to 1950 F.

Tempilaq is a lacquer-like liquid which, after drying, will melt at a certain predetermined temperature. With the addition of the new temperature range, Tempilaq is available in quantities which melt at specific temperatures from 113 to 400 F in 12½-degree steps and in 50-degree steps from 400 to 1950 F.

Portable Hardness Tester

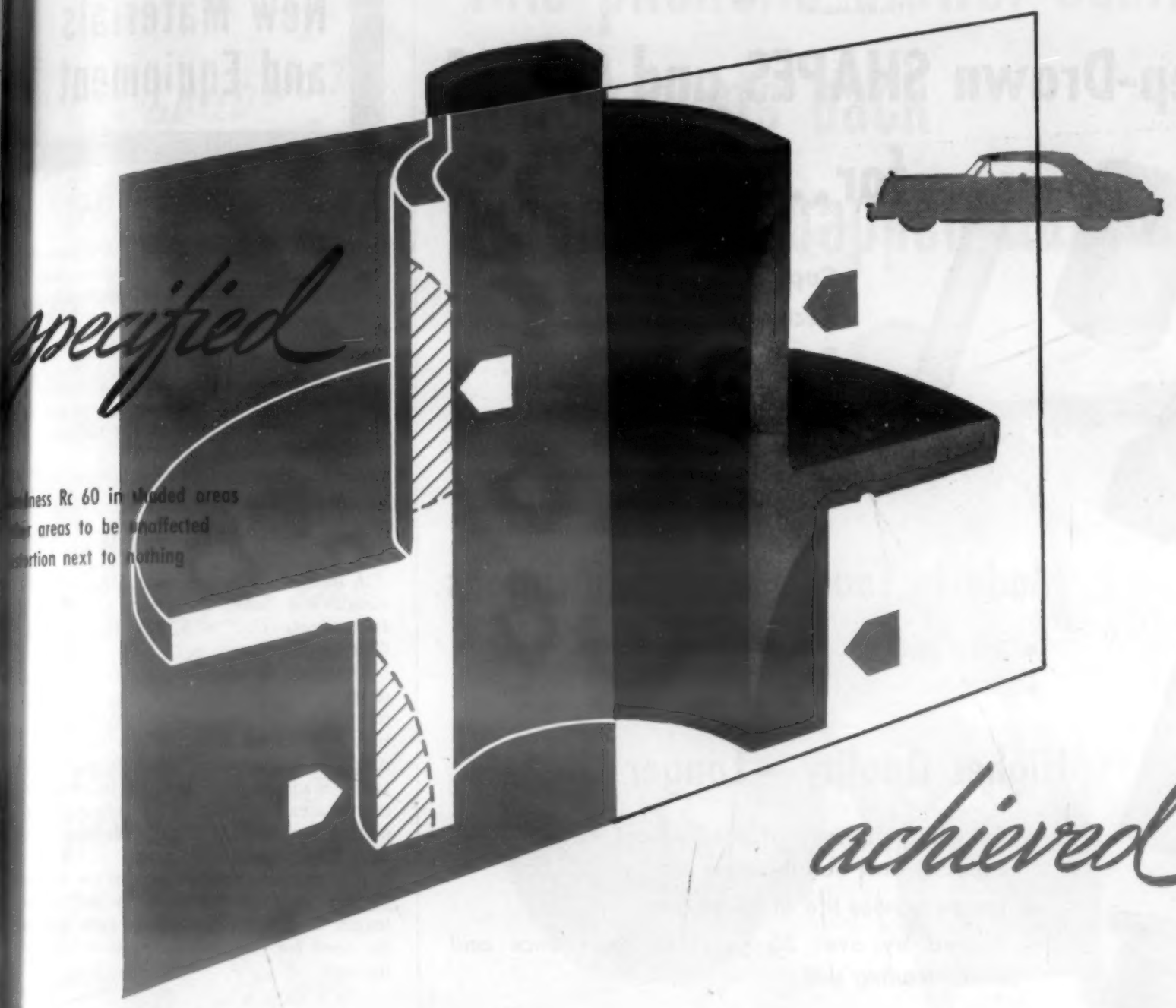
A new, portable, direct-reading Ernst hardness tester is being distributed by *Newage International, Inc.*, 521 Fifth Ave., New York City.

Built as an entirely new tester to meet the demand for a portable, reasonably priced direct-reading tester, it can be conveniently carried and handled, permitting at the same time a direct and completely accurate reading without the necessity of referring to conversion scales or calculations.

With the Ernst tester, "at-the-job" direct readings can be taken on any shape or form of metal, according to the manufacturer, regardless of the size or width of metal.

In use, hand grips on the side of the instrument are pressed downwards to lower the indentor so that its point penetrates into the surface of the material being tested. The movement of the indenter into the

another part for a torque converter transmission



see this flamatic hardening job in action at the Metal Show

Cincinnati Flamatic surface hardening of the hub of a new automatic torque converter transmission will be shown **in action** —in actual production—at the Metal Show (Chicago International Amphitheatre, October 23-27). This exceptional job is one of the many presented **in print,** with complete data on hardness patterns, metallurgy, and production rates, in the brand new catalog on the Cincinnati No. 2 Flamatic Hardening Machine. See the Flamatic exhibit at the Show—and get your copy of the new catalog: Publication No. 1724.

flamatic

THE CINCINNATI MILLING MACHINE CO

Cincinnati 9, Ohio, U.S.A. • CINCINNATI

Insist on *Prest-O-Lite*
Trade-Mark

Deep-Drawn SHAPES and SHELLS for...

Cups
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Made to Your Exact Specifications

- In conventional or unusual contours
- With or without openings, fittings or brackets

Higher Quality—Longer Life

- Extreme uniformity of size, weight, strength, capacity and wall thickness
- Longer service life at lower cost
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LINDE engineers will gladly help you with your designs, specifications and production problems involving cold-drawn shells and shapes or formed metal parts. Just mail the coupon for full information.

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Send literature and full information about deep-drawn shapes and shells.

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COMPANY_____

ADDRESS_____

New Materials and Equipment

material is magnified about 3000 times b displacing liquid from a container into capillary tube. The tube is supported in recess and encircles the scale so that th final position of the liquid indicates th hardness value directly.

Except when the radius of curvature i less than 3/32 in., the instrument can be used on curved as well as flat surfaces.

Molten Metal Thermocouple

A molten metal thermocouple for ferrous metals has been developed by *Wheelco Instruments Co.*, 865 W. Harrison St., Chicago 7.

Designed to withstand melting temperatures up to 3200 F and all casting temperatures normally encountered in the production of precision steel castings, the thermocouple is said to allow temperature readings to be made in less than 30 sec. with extreme accuracy. It has an adjustable extension and uses a 27-gage platinum-platinum 10% rhodium element.

A telescoping feature permits the feeding of the platinum element to the proper length within the protecting tube without the need for cumbersome re-assembling of the unit.

●

Heating, Heat Treatment

Induction Pinion Heater

Much of the difficulty formerly involved in removing pinions from shafts is said to be eliminated by the use of an induction pinion heater manufactured by *National Electric Coil Co.*, 794 Chambers Rd., Columbus 16, Ohio.

With the National induction heater, heat is generated within the pinion, expanding it and allowing it to be removed with light pressure. Older methods required tons of pressure or excessive heat to remove the pinion, sometimes damaging both pinion and shaft. The heater is insulated with AIEE Class H materials, insuring long life. It is easily operated by one man, and eliminates the hazards present in ordinary pinion removal.

MR. PRODUCT DESIGNER

Here's a small application with big advantages. you may be able to apply a versatile Monsanto plastic to your design and production problems. For skilled technical advice and assistance in plastics, check with Monsanto to day!

"This phenolic drawer bearing rolled costs back when we scrapped habit-itis"

says
WENDELL L. SMITH
Exec. Vice President
A-B Stoves Division
Detroit-Michigan Stove Co.

Sturdy, silent stove drawer bearings molded of Monsanto Resinox by The W-L Molding Company, Kalamazoo, Mich., for A-B Stoves Division, Detroit-Michigan Stove Company.

Phenolic plastic bearings molded of Monsanto's Resinox are now replacing metal rollers in the sliding drawer on A-B stoves because:

The new bearings are mass-molded with metal insert included in one operation that requires no additional machining or finishing. They are free-rolling and, with graphite built right in, need no lubrication. Excellent dimensional stability and high impact-resistance of Resinox and its resistance to heat up to 490°F, more than meet all the requirements. Customers like the quieter, easy operation of the new stove drawers.

It adds up to: lower production costs and higher customer satisfaction.

These advantages—in just one product—are but a few of the many that Resinox offers. And Resinox is but one of many Monsanto plastics, each possessing its own special properties that are already being applied to hundreds of products in scores of industries. It will pay *you* to investigate Monsanto plastics—and learn how they can improve *your* product, or cut production costs, or add sales appeal. Write Monsanto *today*—or use the handy coupon.

Resinox: Reg. U. S. Pat. Off.

MONSANTO
CHEMICALS—PLASTICS
SERVING INDUSTRY...WHICH SERVES MANKIND

MONSANTO CHEMICAL COMPANY
Plastics Division, Dept. MMP34, Springfield 2, Mass.

Please send me information on Monsanto Plastics. My product is _____

Name, Title _____

Company _____

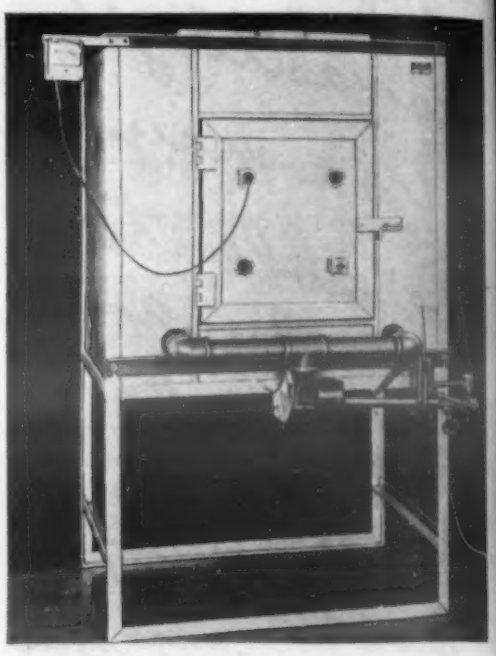
Address _____

City, Zone, State _____

New Materials and Equipment

Heat Treating Furnace

A. D. Alpine, Inc., 11837 Teale St., Culver City, Calif., has introduced a new line of precision furnaces for the heat treating of metals. Available in capacities ranging from 1.8 to 20 cu. ft., with a range of from 0 to 2500 F, these Alpine furnaces are



Here is one of a new line of Alpine precision heat treating furnaces, available in capacities from 1.8 to 20 cu. ft.

equipped with porcelain-protected thermocouples and direct-reading pyrometers with calibrated energy input and atmosphere proportioning.

Safety is insured by means of a solenoid valve, which cuts off the fuel in the event that an electrical failure stops the blower, then automatically relights and resets the fuel input when the electrical failure has been corrected. Insulation of the furnace is said to have been perfected to the point where the outside temperature of the furnace is approximately 150 F at the height of operation.

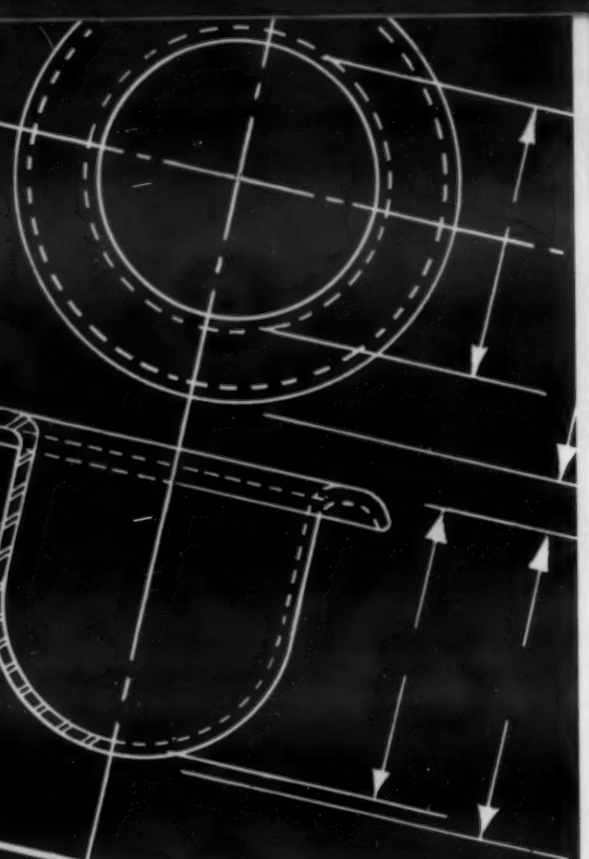
Oil and Gas Burner

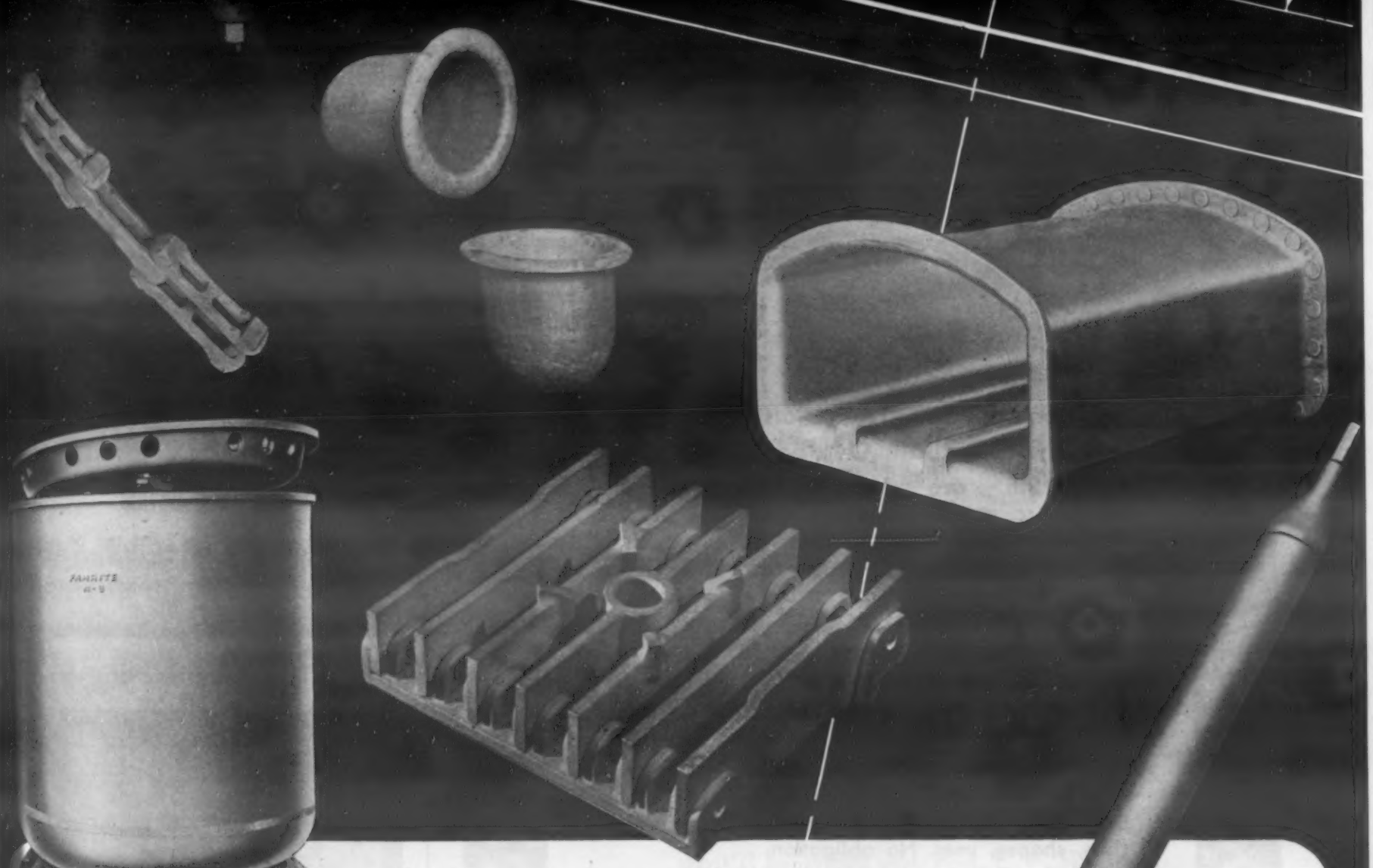
Designed for all furnaces requiring high temperatures and intense transfer of heat to materials, a new combination gas and oil burner is being manufactured by *Bloom Engineering Co., Inc.,* 857 W. North Ave., Pittsburgh 33, Pa.

Heat releases up to 750,000 Btu. per cu. ft. of combustion volume can be obtained with the High Thermal Release (HTR) burner, according to the producers, yet a turndown ratio of greater than 10 to 1 enables low input for holding purposes. Recommended for applications where quick

FAHRITE

HEAT AND CORROSION *Alloys*





WHEREVER HEAT OR CORROSION IS A PROBLEM

Put FAHRITE on the job for sustained, higher production at lowest cost. FAHRITE has proved its heat-resisting ability in retorts, hearths, carburizing boxes, trays, chains, fixtures and centrifugally cast tubes. Whatever your operating conditions, a FAHRITE engineer will recommend the proper grade alloy to meet your requirements.

Ohio Steel ranks high in three essentials: 1. Design 2. Metallurgy 3. Ability to make a good casting.

THE OHIO STEEL FOUNDRY COMPANY

SPRINGFIELD, OHIO — Plants at Lima and Springfield, Ohio

in BURNISHING MATERIALS

the BALL rolls 'em SMOOTH

For smooth, even roll-down burnishing of flat and gently curved surfaces . . . use Abbott "Eclipse" or "Abco" Burnishing Balls. They're *sure* to do the job right!

Abbott Burnishing Materials, available in five shapes — Ball, Ovalball, Diagonal, Cone, Pin — are scientifically designed to make effective contact on metal stampings or castings of any size and shape. Each piece is a burnishing tool made from Abbott's high quality bearing ball steel. Each is deep hardened and polished to a mirrorlike, glasshard finish. For *better* all 'round burnishing results . . . use Abbott!

Some parts require a special mixture of Abbott Burnishing Materials. Send for catalog showing sizes, shapes, uses. No obligation.

THE ABBOTT BALL COMPANY

1074 New Britain Ave., Hartford 10, Conn.

ABBOTT

the all round ball

New Materials and Equipment

heating with a small furnace has definite advantages, the HTR burner is said to differ from conventional designs in that fuel and combustion air are pre-mixed within the alloy nozzle, forming a uniform, combustible mixture when discharged into the furnace.

The nozzle, made of a heat resistant alloy, reportedly is safe to operate when subjected to a furnace temperature as high as 2800 F, and is designed to prevent the flame from traveling back, regardless of the rate of flow. Flame characteristics are said to be identical using either gas or oil, the changeover from one fuel to another accomplished merely by closing one set of valves and opening the other.

General

Porosity-Eliminating Device

Porosity of small cast parts can be eliminated with new high-pressure equipment developed by *Tincher Products Co.*, 872 Borden Ave., Sycamore, Ill.

Designed for use in the Tincher process for reclaiming porous castings that must withstand liquid and gas pressures, the new

This new Tincher high-pressure unit eliminates porosity in small cast parts.

device treats all internal and external surfaces simultaneously.

Either before or after machining, cast parts are placed in a wire basket which is lowered into the pressure tank. High pressure is then used to force the sealing agent into the tank and into all pores and voids in the casting. After treatment, which does

There's a place for Houghton in this picture

The gentleman is in conference — with himself. The time, we hope, is after 5:30. The place could be the office of any metallurgist who is thinking through to 1951.

Going through his mind in this after-hours thinking are the problems facing him in the near future — the need for increased production and how to meet it.

He's wondering, perhaps, how to speed up his heat treating, or how to get higher hardnesses, or how to eliminate distortion. He may be considering the greater use of salt as a heating medium . . . or obtaining of better drawing compounds for cold forming . . . or a more efficient coolant for machining, which will enable faster production.

Houghton can be — should be — in the picture. This service organization of ours attained its growth through the years solely by rendering on-the-job aid to men like him. If the ideas are sound, our products naturally follow.

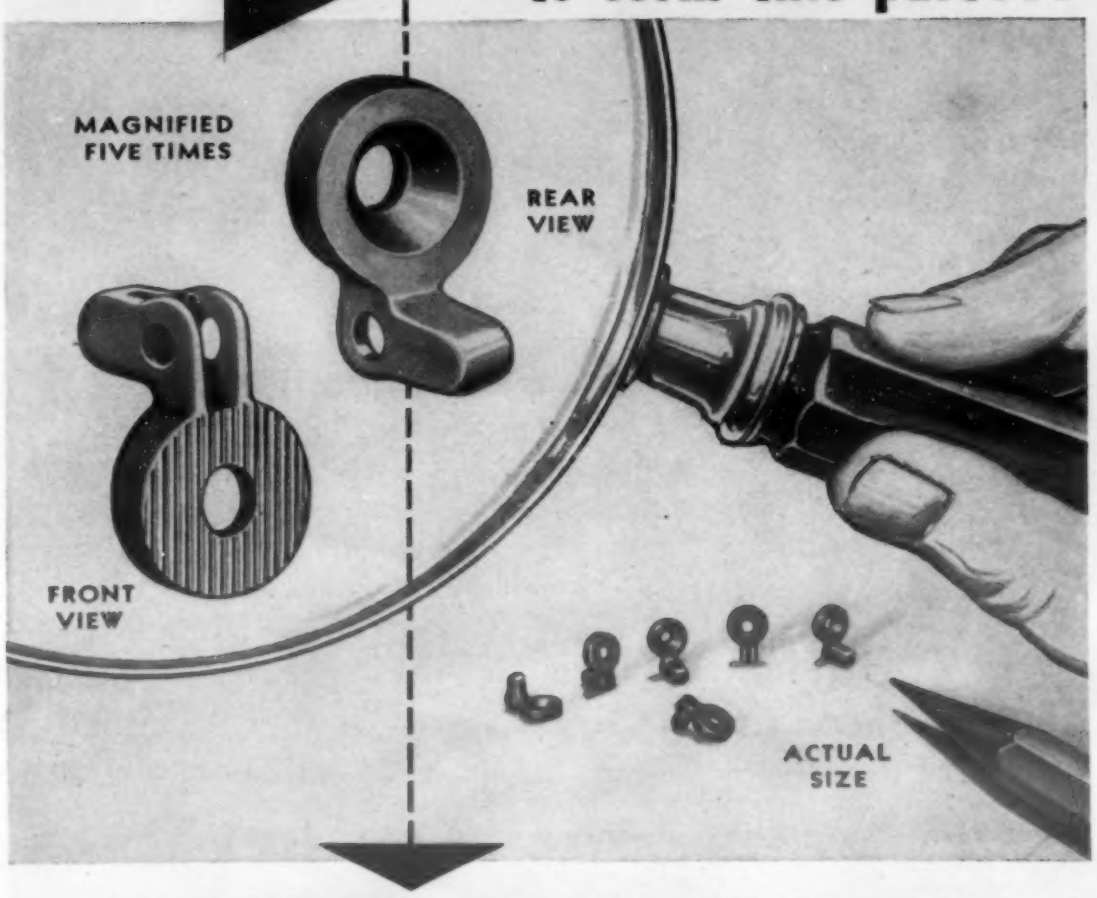
So when you're thinking ahead, put Houghton in the picture. Consider our 85 years of metal-working experience, our broad program of shirt-sleeved research, our personal plant help. When 1951 rolls around you'll be glad you did. E. F. Houghton & Co., Philadelphia and all principal cities.

The Houghton Line of metal-working products:

Heat Treating Salts, Carburizers, Quenching Oils, Cutting Oils, Rust Preventives, Cleaners, Drawing Compounds, Pickling Inhibitors, Lubricants.

Serving Industry Since 1865

There is one RIGHT WAY to form this part...



A PRECISION INVESTMENT CASTING

by HITCHINER

Illustrated is one of the *world's smallest industrial castings*, a rifle peep sight made by the Hitchiner method of investment casting for Lyman Gun Sight Corporation. This part is of Beryllium-Copper, heat-treated to Rockwell C-42 to provide a spring temper.

It will pay you to investigate the Hitchiner method of precision investment casting. Here is why:

- **Low Tooling Cost:** Cost of tooling is low compared to most other methods of manufacture. Very little set-up time is required to make short runs and, for quantity production, a minimum of extra tooling is needed.
- **Wide Choice of Materials:** Practically all ferrous and non-ferrous alloys can be cast including those difficult to machine or forge.
- **Complex Shapes:** The Hitchiner process is particularly adapted to complex parts with high machining costs, projections, recesses and under-cuts that ordinarily present difficult machining operations or assemblies.
- **Finishing:** Hitchiner castings have fine, sharp detail and smooth finish. In most cases no further machining other than the removal of the gate is required.

Send us your blue prints and permit our metallurgical and engineering staff to provide competent advice on your small metal parts problems.

HITCHINER MANUFACTURING CO., INC.

Manchester, N. H.

Sales Office: 967 Farmington Ave., West Hartford 7, Conn.

AGENTS IN ALL PRINCIPAL CITIES

New Materials and Equipment

not require washing or curing, it is claimed that no evidence of impregnation will remain.

Ultra-Violet Mineral Light

Two new ultra-violet Mineralights which are said to meet every need for fluorescent analysis have been developed by *Ultra Violet Products, Inc.*, Pasadena Ave. at Sycamore, South Pasadena, Calif.

Model SL 2537 Mineralight is a short wave lamp generally used for laboratory research, mineral prospecting, and collecting. The wave length generated is particularly valuable for identifying mercury ore, uranium ore, and sheelite, an ore of tungsten.

Model SL 3660 is designed for general laboratory research, diagnostic use, tracing and criminology. It is especially efficient in oil analysis, and many other minerals respond brilliantly to the long wave length produced by this lamp.

Both Mineralights operate on 110-v. a.c. current or on two B batteries of 45 v. each. The latter method is valuable in field work. Self-insulation and rugged construction in both Mineralights is provided with a lightweight Durez case.

Radiation Counter

A new instrument for the detection and counting of alpha, beta and gamma particles has been announced by the *Special Product Div.* of *General Electric Co.*, Schenectady 5, N. Y.

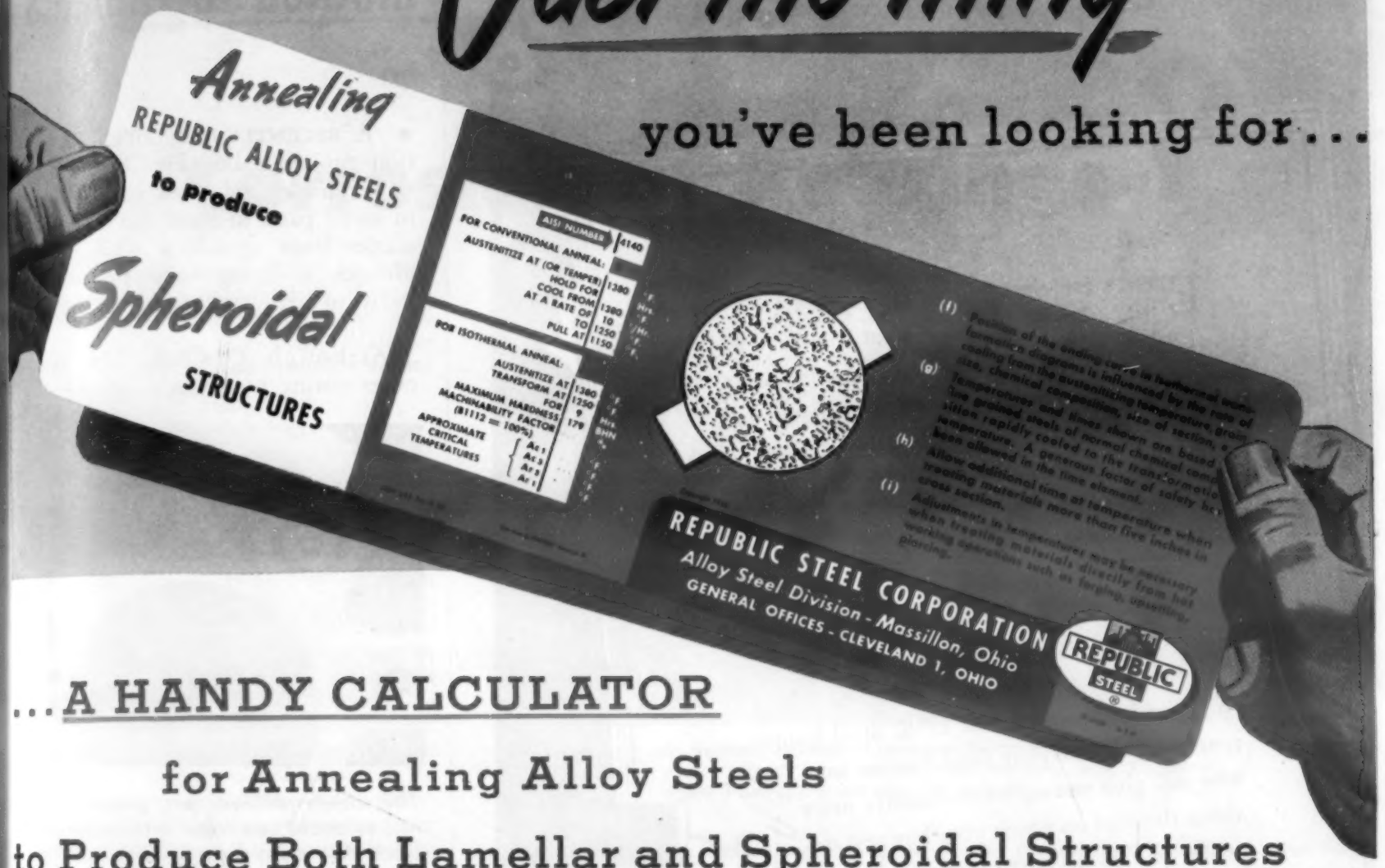
Called a "universal scintillation counter,"

This new G.E. radiation counter is said to offer several advantages over more conventional instruments.

the device provides low background alpha counting and high efficiency beta and gamma counting. It is intended for use in counting samples and smears in health physics work, for analytical determination of disintegration rate, and in counting radiation of ore samples.

Just the thing

you've been looking for...



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to Produce Both Lamellar and Spheroidal Structures

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This handy slide calculator provides data on standard AISI analyses ranging from 1035 to 9850—for both conventional and isothermal anneal. One side gives information for producing lamellar structures, the other for spheroidal structures.

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News about steel

FROM U·S·STEEL SUPPLY

EVENTS are changing so rapidly today that it is difficult to predict what lies ahead for the steel industry and its customers. However, we are in constant touch with Washington and our mill sources, and we will do our best to keep you advised about the steel situation as it affects you.

The latest news about the availability of steel in various sizes, forms and specifications, about acceptable substitutes and delivery dates . . . this type of information will always be as close to you as your telephone. We invite you to consider your U. S. Steel Supply representative as your Steel Service man who will give you up-to-the-minute news about the steel on which your business depends, and do his best to help you locate a supply.

And, of course, it goes without saying—we shall continue to give you the best possible steel supply service in the industry. Although some items are in short supply, our diversified stocks in 14 warehouses still add up to a lot of steel. Perhaps they contain exactly what you want. It will pay to check first with U. S. Steel Supply when you need steel.

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USS

UNITED STATES STEEL

A New Inspection Method for Metals

• A RECENTLY-DEVELOPED inspection process called Dy-Chek, which causes cracks and other surface flaws in metal parts to stand out as telltale scarlet lines against a white background, is being used successfully today in many industrial testing applications.

Although Dy-Chek, like many other testing processes, is suitable for

Two clearly defined, but previously unnoticed cracks were found in this automobile block when it was given Dy-Chek inspection.

mass production inspection of parts under factory conditions, it is especially valuable for examining equipment in the field, since individual parts can be tested without removing them from their place. The crankshaft of an engine, for instance, can be inspected without being disconnected—as long as it can be seen and reached.

Simple Process

Requiring only from five to ten min. (depending upon how clean the surface is) for completion, the Dy-Chek process can be easily learned by inspectors and skilled mechanics. To begin the inspection, a non-corrosive red dye penetrant is applied to the surface of the part and allowed to stand for a few minutes. It is then removed with a special cleaner and dye remover and replaced with a white developer solution. Any surface openings existing in the part can then be detected by the presence of fine red lines or dots created as the red dye, possessing extremely high capillary action, is drawn from the fissure by the developer.

Some variations of this method have already been developed in industry. In checking thick pump cast-

JOHNSON BRONZE

SLEEVE BEARING DATA

Bearing DESIGN

JOHNSON BRONZE

SLEEVE BEARING DATA

Corrosion of Bearings-1

ALL bearing materials should be fabricated to meet requirements of corrosion resistance. These requirements are of two distinct types. Corrosion resistance prior to installation and corrosion resistance after installation.

Prior to installation, bearings may corrode during shipment or in storage. The corroding medium usually is water or water vapor due to occasional exposure to high humidity or actual condensation of water where cold metal is brought into a warm room under such conditions that the temperature of the metal is below the dew point. In some rare cases corrosion may be caused by certain gases present in the atmosphere. These instances should be given individual study in order to arrive at the proper preventive. The resistance of the bearing metals to corrosion due to water or prior to installation is of a different order than corrosion resistance under operating conditions. In this first treatise we will limit the discussion to the former.

The approximate tendency to corrode in the presence of water is shown in figure No. 1, under room temperature conditions. Steel is the most sensitive of all the materials used and precautions have to be taken to protect the steel against rusting. The amount of protection required depends on the expected time of exposure to atmospheric conditions. If steel-backed bearings are to be placed in service shortly after manufacture, then a light film of oil will suffice. For periods of protection up to six months an electro-deposit of tin or a heavier oil coating is used. For periods of protection up to two years an electro-deposit of tin, plus a light grease is used. For longer periods or for overseas shipment a heavy grease is often used.

An excellent example of resistance to corrosion is this old bronze anchor recently dredged up from Monterey Bay, California, where it had lain in *salt water* for over 300 years

A protective oil is required for lead-base babbitt for storage periods longer than six months.

Both steel and lead-base babbitt are characterized by pitting when corrosion due to water vapor takes place. A few pits will not harm either of these materials but extensive corrosion may result in undesirable dimensional changes.

Copper-lead will corrode because the lead phase is exposed but the lead is isolated in small areas and not subject to the more extensive attack of lead-base babbitt.

Tin base babbitt, bronze and aluminum may stain on exposure to the atmosphere but damage due to corrosion under these conditions is practically unknown.

The corrosion of bearings under service conditions is due to entirely different factors than under storage conditions.

Service conditions are discussed in data sheet . . : Corrosion-2.

Engineering Service

Johnson Bronze offers manufacturers of all types of equipment a complete engineering and metallurgical service. We can help you determine the exact type of bearing that will give you the greatest amount of service for the longest period of time. We can show you how to design your bearings so that they can be produced in the most economical manner. As we manufacture all types of Sleeve Bearings, we base all of our recommendations on facts free from prejudice. Why not take full advantage of this free service?

●

This bearing sheet data is but one of a series. You can get the complete set by writing to—

SLEEVE BEARING HEADQUARTERS
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Relative Comparison of Corrosion

Fig. 1 Tendency of bearing material to corrode in the presence of water vapor at room temperature.

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Resist Sulphuric Acid Attack

Valve Bodies and Fittings cast at Lebanon in various special sulphuric acid resistant alloys.

FOR CHEMICAL AND PROCESS INDUSTRY APPLICATIONS . . .

DURING the period of development of special alloys to resist sulphuric acid and sulphuric and nitric acid combinations, Lebanon played an important part in proving their value as casting material. Lebanon Circle L 34 (Stainless Type FA 20*), analysis of which is given below, is an alloy created to meet this demand. Circle L 34, in addition to its resistance to sulphuric and nitric acid, offers good resistance to alkalis and alkali salts.

Our familiarity with the manufacture of castings of special alloy materials means that we can readily meet your requirements. Every Lebanon casting is made to exacting standards, inspected and thoroughly tested before shipping. A complete laboratory, including a million-volt X-Ray machine, is one of the facilities upon which our customers constantly rely.

Do you have copies of the Lebanon Data Sheets? If not, just let us know and we will send them along to you.

LEBANON CIRCLE Ⓛ 34

NOMINAL ANALYSIS

Carbon Max.	0.07 Max.
Silicon	1.25
Manganese	0.75
Chromium	20.50
Nickel	28.50
Molybdenum	2.50
Copper	4.25

NOMINAL PHYSICAL PROPERTIES

Tensile Strength	72,000
Yield Point	35,000
Elongation in 2"—%	45
Brinell Hardness	150

Heat treatment: Water quenched.

*Circle L 34 (FA 20) DuPont Specification 1364

LEBANON STEEL FOUNDRY • LEBANON, PA.
"In the Lebanon Valley"

LEBANON ALLOY AND STEEL Castings CIRCLE L

A New Inspection Method

continued from page 138

ings, for example, one manufacturer applies the Dy-Chek red dye penetrant to the *inner* surfaces of the casting and the white developer to the outside. Wherever porosity or cracks occur, red stains appear on the outside of the casting, indicating that the dye has found its way completely through the 2-in. thick wall.

Test Indications

Experience soon enables an inspector using the Dy-Chek process to estimate, with some accuracy, the size and depth of the surface discontinuities. Thus, a line of small dots of red dye indicates a very fine crack, the width of which can be estimated to some extent by the spacing of the dots. Scattered dots, on the other hand, indicate porosity in the part. The volume of the discontinuity can be estimated by the amount of "bleeding" or spreading of the dye on the developer.

Many advantages have been claimed for the new process over available inspection methods. They include

Dy-Chek indications sometimes occur in the form of a thin line of red dots, revealing the presence of an extremely fine crack.

(1) its relative inexpensiveness, (2) its simplicity, (3) its application to both ferrous and nonferrous metals, and (4) its portability. Unlike a few of the other inspection methods, however, Dy-Chek does not detect sub-surface flaws.

Plans are now in progress to broaden the use of Dy-Chek to such industries as oil production, refining, transportation, marine construction and operation, the heavy construction equipment field, mining, and printing. It will be marketed by the Dy-Chek Co., a division of Northrop Aircraft, Inc.

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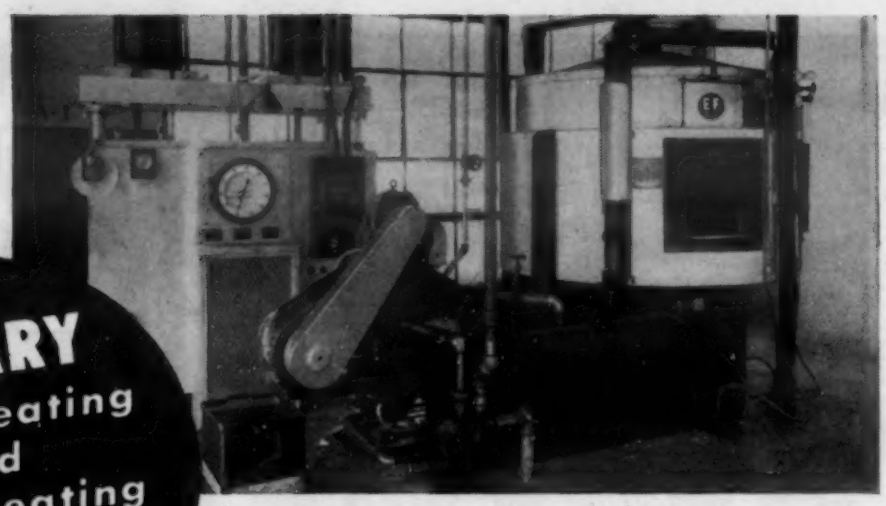

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News Digest

continued from page 7

creased with aluminum content up about 6.5% aluminum. Specimens stressed in Washington weather fail more quickly than those subjected the same stress in the marine atmosphere. On the other hand, damage unstressed specimens at Washington was small as measured by losses tensile properties.

Resistant Alloys

Of all the materials studied, the M1-clad AZ31X-h alloy was the most resistant to stress corrosion. Specimens of this alloy were exposed in marine atmosphere, stressed to 30,000 psi. (90% of yield strength), for 50 days without failure.

Among the bare alloys, M1-h sheet and ZK60 extruded material were outstanding in stress-corrosion resistance. After 1175 days of Washington exposure under 16,000 psi. (55% of yield strength), the M1-h sheet alloy had not failed. First failures of ZK60 stressed at 20,000 psi. at the same place occurred only after 580 days; specimens stressed at 18,000 psi. have not failed in more than 1010 days.

Susceptible Alloys

Of the remaining alloys, bare AZ31X-h proved most resistant. However, specimens of this material stressed to 16,000 psi. (about 50% of yield strength) and exposed to Washington weather failed after an average of 151 days. The AZ51X, AZ61X and AZ80X alloys were all susceptible to stress corrosion when exposed at 20,000 psi. or more. Extruded AZ80X was more resistant to stress corrosion in the heat treated and aged condition (AZ80X-HTA) than in the "as extruded" condition.

Western Steel Capacity Boosted

Expansion of steel mill capacity in the Far West is being undertaken by two subsidiaries of U. S. Steel Corp. This expansion reflects the growing market for steel on the West Coast as well as an expected increase in defense needs.

According to an announcement from Columbia Steel Co., additional cold reduced sheet and tin plate

"I wasn't asleep," said the Dormouse

EVERY boy and girl knows the drowsy Dormouse of Alice in Wonderland. He was elbowed and pinched by the Mad Hatter and the March Hare as he mumbled in his sleep at the tea party.

But our young people aren't so well versed in everyday economics. They have a sadly distorted picture of the profits of business. They don't realize why profits are necessary, how small they are, or how they are divided.

For instance, in a recent survey of high school seniors, it was discovered that they believe over 50% of the sales dollar is profit and they think stockholders receive 24% of it. Actually business profit averages less than 8%, with less than 3% distributed as dividends. Business uses most of its profit, moderate as it is, for new plant and equipment, to improve products and to make more jobs.

Misconceptions among our youth bode ill for America's future. They open the door for too ready acceptance of dangerous isms and false foreign philosophies. Such misunderstanding of economics can be corrected only with facts supplied by business itself. You as a leader in your community must share this responsibility.

The American business man must not allow himself to be cast in the role of the Dormouse, pinched and pilloried by the March Hares of communism and the Mad Hatters of the "everything for nothing" state.

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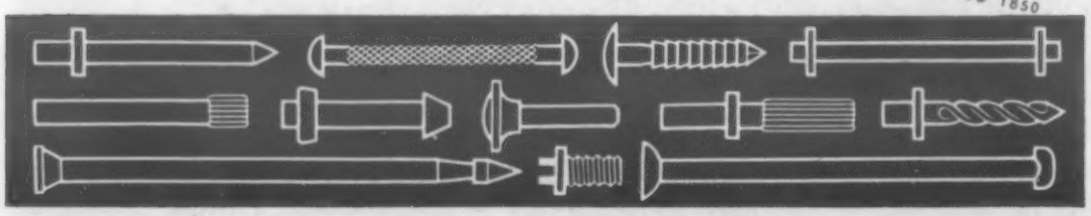


News Digest

facilities will be installed at its Pittsburgh, Calif. plant. The new facilities will have an annual capacity of about 215,000 net tons. The new mill is expected to be in operation in slightly less than a year.

At the same time, Geneva Steel Co. is planning new facilities at its Geneva, Utah plant, which will add 100,000 net tons of hot rolled sheet to its annual capacity.

Bi-Metallic Stator Blades Studied

Bi-metallic gas turbine stator blades, having aluminum roots for easy machining, are under study in England, according to a recent announcement by Wellworthy Astons, Ltd. This company is holder of the British license for the Molecular bonding of aluminum to steel by the Al-Fin process, developed by Fairchild Engine & Airplane Corp., Farmingdale, N. Y.

Primary object of the study is the development of a rapid, economical method of manufacturing compressor stator assemblies. It is thought that segments containing a number of blades or even complete stage rings with integral blade sections could be produced with resulting cost and weight advantages.

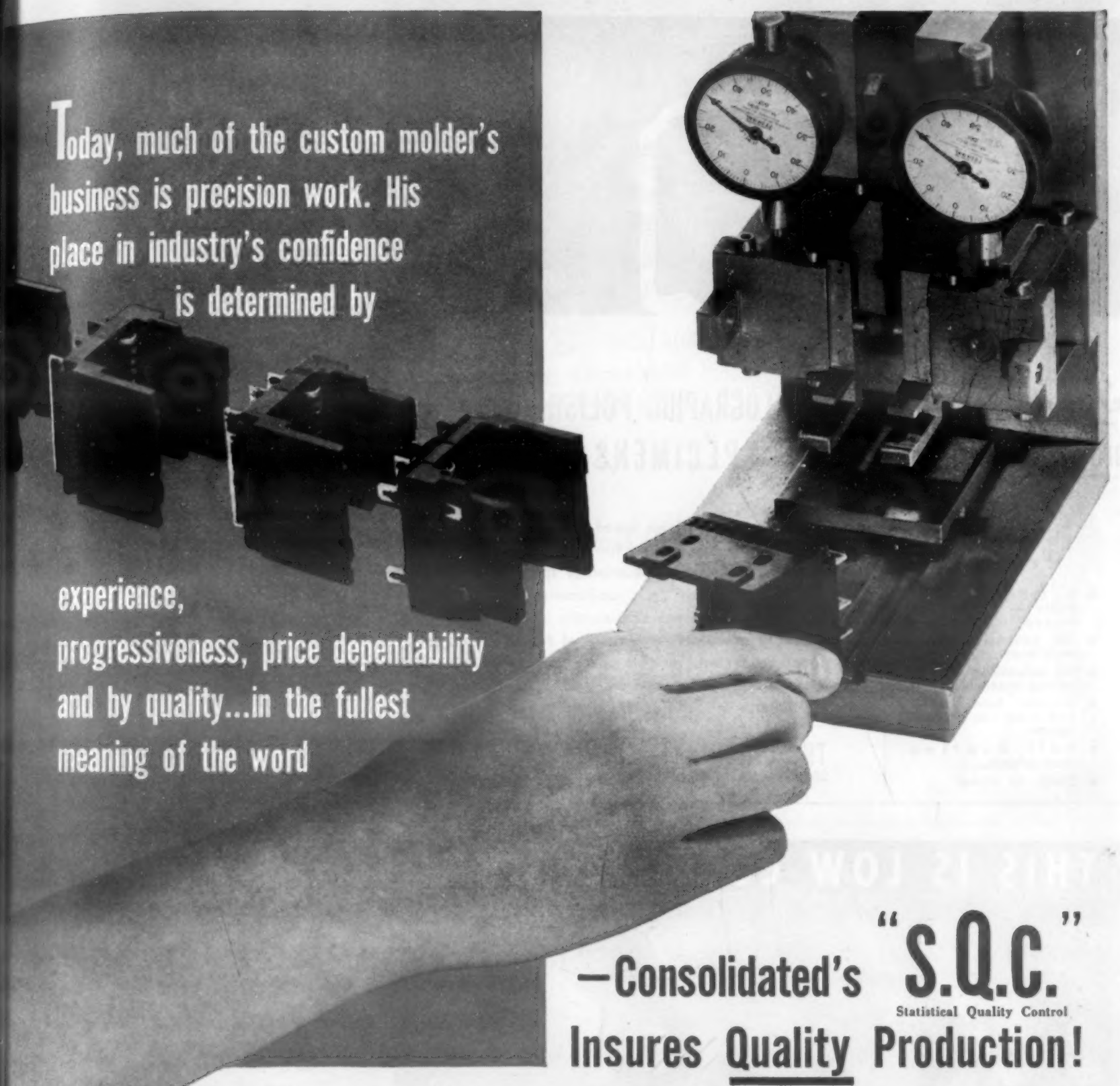
Nodular Iron Uses Outlined

A comprehensive summary of the properties and expected fields of application of nodular iron was given in a paper presented recently by A. B. Everest at the annual meeting of the Institute of British Foundrymen. The paper was published in *Foundry Trade Journal* (July 20, 27, 1950).

The author summarized available data on physical properties and fabrication of ductile cast irons. In addition, he concluded that these irons would be used principally where:

1. Improved toughness and shock resistance are required. Here the irons can be used as-cast.

2. Maximum toughness, ductility and shock resistance are required. Here a dead anneal is generally used, although with particular composi-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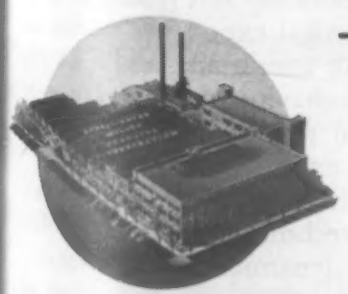

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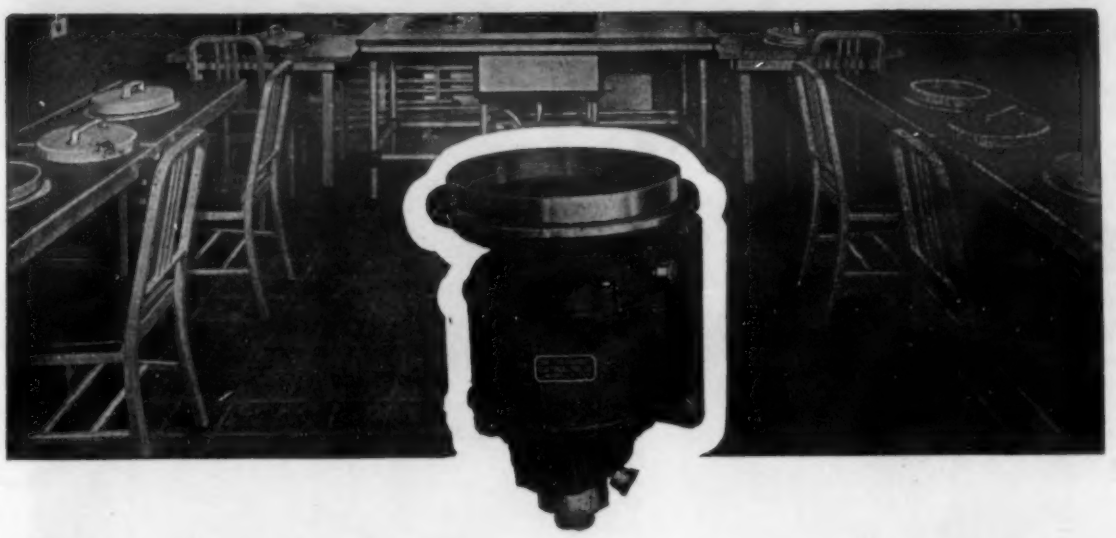

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Every requirement for faster, better positioned welding—constant or variable speed table rotation, full 135° tilt, self-locking gearing which holds the table in any position, oversize built-in main tilt and rotating bearings, choice of two base styles, and many other features—are built into C-F Positioners.

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CULLEN-FRIESTEDT CO., CHICAGO 23, ILL.

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News Digest

tions the desired properties can be obtained as-cast.

3. Reduction in section, made possible by higher mechanical properties, leads to a saving in weight.

4. Toughness and ductility are required in heavy-section castings, beyond the scope of malleable practice.

5. Steel castings are now used only because gray cast iron properties were inadequate and production by the malleable process was not feasible.

6. Special-purpose irons are needed, *e.g.*, austenitic cast irons with improved mechanical properties.

Beryllium Effects Reviewed

Industrial health hazards resulting from the handling of beryllium and its compounds and ways of controlling them are reviewed in a booklet recently issued by the Bureau of Mines.

Information Circular 7574 can be obtained free of charge from the Publications Distribution Section of the Bureau of Mines, 4800 Forbes St., Pittsburgh 13.

ASTM Publications Released

Two new publications have been issued by the American Society of Testing Materials. One is a 236-page "Symposium on Evaluation Tests for Stainless Steels," the report of a conference sponsored by Committee A-10 during the 1949 ASTM meeting. It presents a critical appraisal of some of the testing methods regularly used for evaluating certain corrosion resistant characteristics of these alloys. Special attention is given to (1) the significance of laboratory test results in relation to practical experience under diverse service conditions, and (2) the effects on behavior of stainless steels, in tests and use, of lowering carbon contents to extremely low limits.

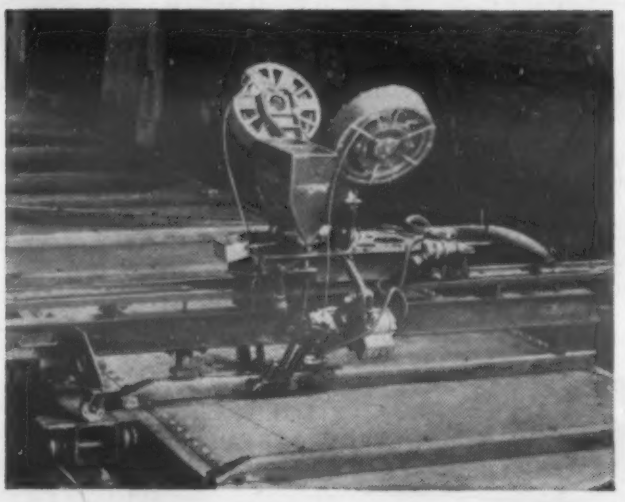
The other booklet, 64 pages, contains four technical papers and a discussion on dynamic stress determinations. This symposium, presented at the Pacific area national meeting of the ASTM in 1949, summarizes available information on the scope, applicability and limitations of electronic

Ideas on Welded Design—For the Engineer's Notebook

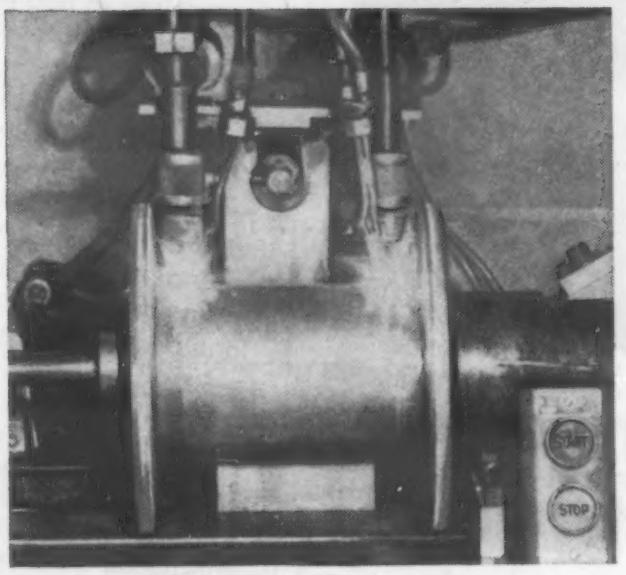
MAKE WELDS SIMULTANEOUSLY

When both ends or both sides of an object must be welded, both welds can often be made simultaneously. Production can thus be doubled — welding time cut in half!

Two UNIONMELT welding heads or two HELIARC torches can often be used — with the weldment turning or moving under stationary welding equipment, or with the welding units moving over the workpiece. Here are examples:



Two UNIONMELT welding heads are simultaneously welding both sides of a stake, joining it to the side panel of a railroad car. The bridge that supports the carriage can be easily shifted for welding both the stakes and diagonal side braces.



Fabrication of aluminum spools is speeded by use of two stationary HELIARC welding torches. The formed ends are joined to the barrel by girth butt welds. The pieces are held together over a backing mandrel, and turned under the HELIARC torches which make both welds simultaneously.

Better design for welding will help cut costs and increase production. For further information, call or write our nearest office.

Visit our booth (1001) at the National Metals Exposition, October 23-27, Chicago, and learn more about these processes. Plan to attend the American Welding Society's special session on "Design for Production Economies," October 24.

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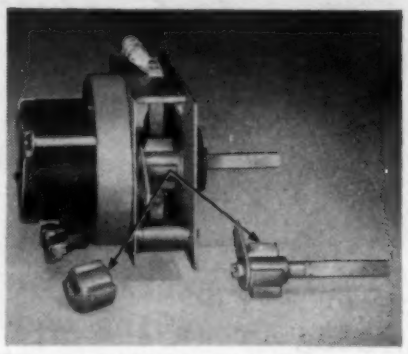
P. R. Mallory and Co. tells how... Nonferrous Powder Metallurgy Pays Off!



For its washing machine timer cam, Mallory wanted critically close tolerances *plus* corrosion resistance combined with high density and strength. And all at pencil-sharpening low cost!

By having Indar Corporation fabricate the part from a Horse Head® brass powder, Mallory designers can now report:

ROCK BOTTOM COST. No heavy tooling costs were needed. Nonferrous powder metallurgy is a high-speed process involving two straight-line operations—pressing the powder in a die and sintering.

TOLERANCES HELD TO ±.001" on hub and shaft hole diameters . . . .002" on concentricity of hole to cam surface.

DENSITY REQUIREMENTS MET. The cam hub was impregnated with silver which served to increase both density and strength. (Powder metal parts often can be impregnated to advantage with a variety of materials.)

CORROSION RESISTANCE OK. Brass powders shine where good corrosion resistance is needed. And that's true of other nonferrous powders, too, such as nickel-silver.

LET US SEND YOU A SAMPLE *of this brass powder cam. It may suggest how you can use the design advantages of nonferrous powder metallurgy.*

THE NEW JERSEY ZINC COMPANY
160 Front Street, New York 7, N. Y. . . . 221 N. La Salle Street, Chicago 1, Ill.

Phoenixspun

...Solves Fabricating Problems Involved In Radial Contouring

When the design of your products calls for any type of radial contouring, it will pay you to consult PHOENIXSPUN specialists regarding your fabricating requirements. Our experience covers a wide range of industrial applications.

Submit your drawings and specifications for our prompt recommendations and quotations.

PHOENIX PRODUCTS Co.
Metal Spinning Div.
4725 N. 27th Street
Milwaukee 16, Wis.

"JOBS WELL DONE ARE PHOENIXSPUN"

News Digest

measuring and recording devices. Both booklets can be obtained from the Society, 1916 Race St., Philadelphia 3. The first costs $2.50, the second $1.50.

Precision Thermostat Developed for Automatic Furnace Control

A thermostat developed by Dr. William R. Eubank at the National Bureau of Standards is claimed to provide smooth, continuous control of an electric furnace within an extremely small range at temperatures between 1800 and 2800 F.

The new device is of the type in which the furnace winding itself serves as the sensitive element, forming part of a bridge circuit for control of a thyraton tube. The thyraton circuit then acts as a continuously variable valve, allowing just enough current to reach the furnace to compensate for a given temperature fluctuation. The new thermostat is highly sensitive and independent of normal fluctuations in line voltage.

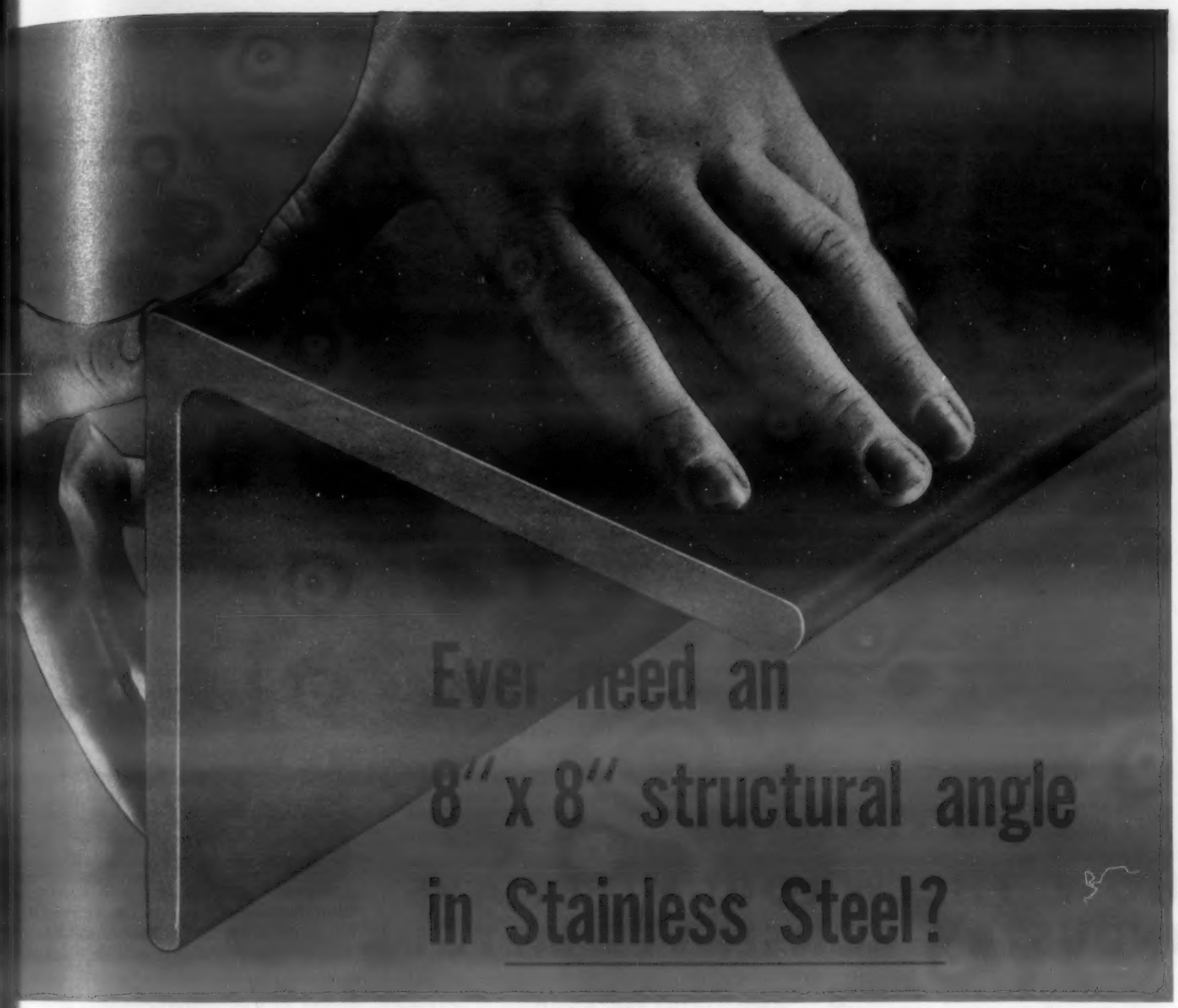
Since it is convenient to operate, easily adjusted for any temperature, and reliable for periods of continuous operation from a few minutes to several days, the device is expected to provide a useful research tool in fields such as metallurgy, ceramics, glass technology and cement chemistry where automatic furnace control has long been a problem.

New Solder for Aluminum Tested

Data on a new zinc-rich solder for aluminum were given in a research report published recently in the British *Metallurgia* (July, 1950). The solder, which appears to be superior to a number of alloys commonly used for this purpose, contains 95 zinc, 5 aluminum and 0.01% titanium.

Tests by C. W. Roberts compared the German-developed solder with five others: 95 zinc, 5% aluminum; 43 zinc, 35 tin, 14 cadmium and 8% lead; 70 tin, 30 zinc, 60 tin, 20 cadmium and 15% zinc; 2.5 copper and 2.5% silver; and 74 tin, 20 lead and 6% zinc. All solders gave joints comparable in strength to welded joints.

Test pieces prepared with 95 zinc



We've made them for others, we can make them for you

(and smaller sizes, too, of course)

YES, we have been supplying these big U·S·S Stainless Steel angles for some time. Many of them have been used for the gateways of flood control dams. And we have made 6" x 4" Stainless angles, too, for the catapult trackways of plane launchers on Uncle Sam's aircraft carriers.

If you are in the market for equally big Stainless Steel angles or for other structural shapes in dimensions beyond the ordinary, here's the place to come.

In U·S·S Stainless Steel, you can obtain not only the widest range of sizes, but a complete selection of compositions and finishes as well. And, in addition, the services of our trained Stainless Steel engineers are available to you. They will assist you in selecting a material that fits perfectly the requirements of the job.

Remember, too, that U·S·S Stainless Steel is a perfected, service-tested material, subjected to stringent control and close observation at every stage of production. It's *made* to give you the finest in Stainless performance.

AMERICAN STEEL & WIRE COMPANY, CLEVELAND · CARNEGIE-ILLINOIS STEEL CORPORATION, PITTSBURGH
COLUMBIA STEEL COMPANY, SAN FRANCISCO · NATIONAL TUBE COMPANY, PITTSBURGH · TENNESSEE COAL, IRON & RAILROAD COMPANY, BIRMINGHAM
UNITED STATES STEEL SUPPLY COMPANY, WAREHOUSE DISTRIBUTORS, COAST-TO-COAST · UNITED STATES STEEL EXPORT COMPANY, NEW YORK

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SHEETS · STRIP · PLATES · BARS · BILLETS · PIPE · TUBES · WIRE · SPECIAL SECTIONS

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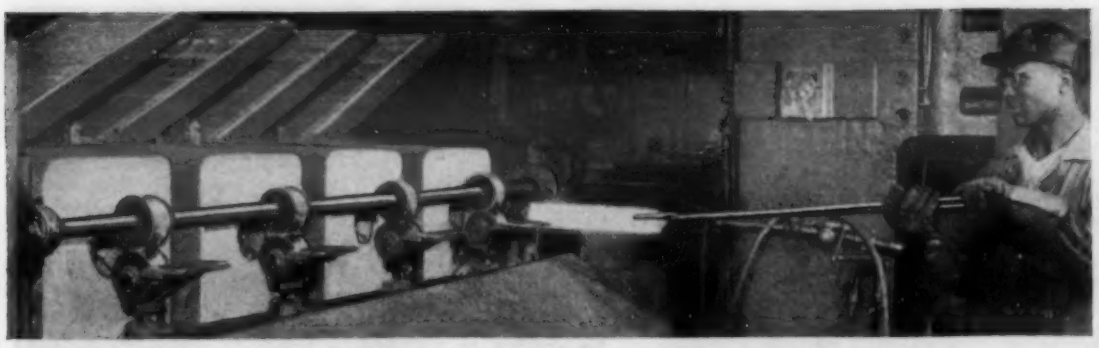
UNITED STATES STEEL



Save Steel WITH SCALE-FREE AJAX-NORTHRUP HEAT

Billets heated to forging temperature by ordinary methods lose from 2 to 6% of their weight in die-wearing, surface-pitting scale . . . a loss that costs from one to five dollars a ton for most high strength alloys. Ajax-Northrup scale-free induction heating eliminates this waste, and gives you better forging to boot! Send for our technical bulletins today . . . find out for yourself how Ajax-Northrup heating can give you better forgings for less money.

AJAX ELECTROTHERMIC CORPORATION • AJAX PARK • TRENTON 5, NEW JERSEY

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AJAX ELECTRIC FURNACE CORPORATION
AJAX ELECTRIC COMPANY, INC.
AJAX ENGINEERING CORPORATION

AJAX NORTHRUP

HEATING & MELTING

132

HOW THE WROUGHT BRASS INDUSTRY CONSERVES METAL

No industry melting *commensurate tonnage** of vital metal can quite match the brass mills for conservation and low melting losses. The savings of metal total millions of pounds; clearly the method they use is worth noting:

Virtually all the brass mills in North America use the Ajax-Wyatt induction melting furnace, for it has the lowest metal losses in the field — less than 1% — with superior temperature control and unapproached economy of operation on high production schedules such as we have today.

The accepted melting tool in brass rolling mills throughout the world.

* *Upwards of 5 billion pounds annually.*

AJAX ELECTRIC FURNACE CORP.
1108 Frankford Avenue • Philadelphia 25, Pa.

THE AJAX WYATT INDUCTION MELTING FURNACE

ASSOCIATE COMPANIES: AJAX METAL COMPANY, *Non-Ferrous Ingot Metals and Alloys for Foundry Use*
AJAX ELECTROTHERMIC CORPORATION, *Ajax-Northrup High Frequency Induction Furnaces*
AJAX ELECTRIC COMPANY, INC., *The Ajax-Hultgren Electric Salt Bath Furnace*
AJAX ENGINEERING CORPORATION, *Ajax-Tama-Wyatt Aluminum Melting Induction Furnaces*

News Digest

and 5% aluminum, with or without 0.01% titanium, retained the highest proportion of their tensile strength after exposure to a variety of corrosive conditions, and in no case did fracture take place by parting at the joint. The relatively high melting point of this alloy, although necessitating some attention to temperature control during jointing, is not expected to affect its usefulness.

News of Engineers

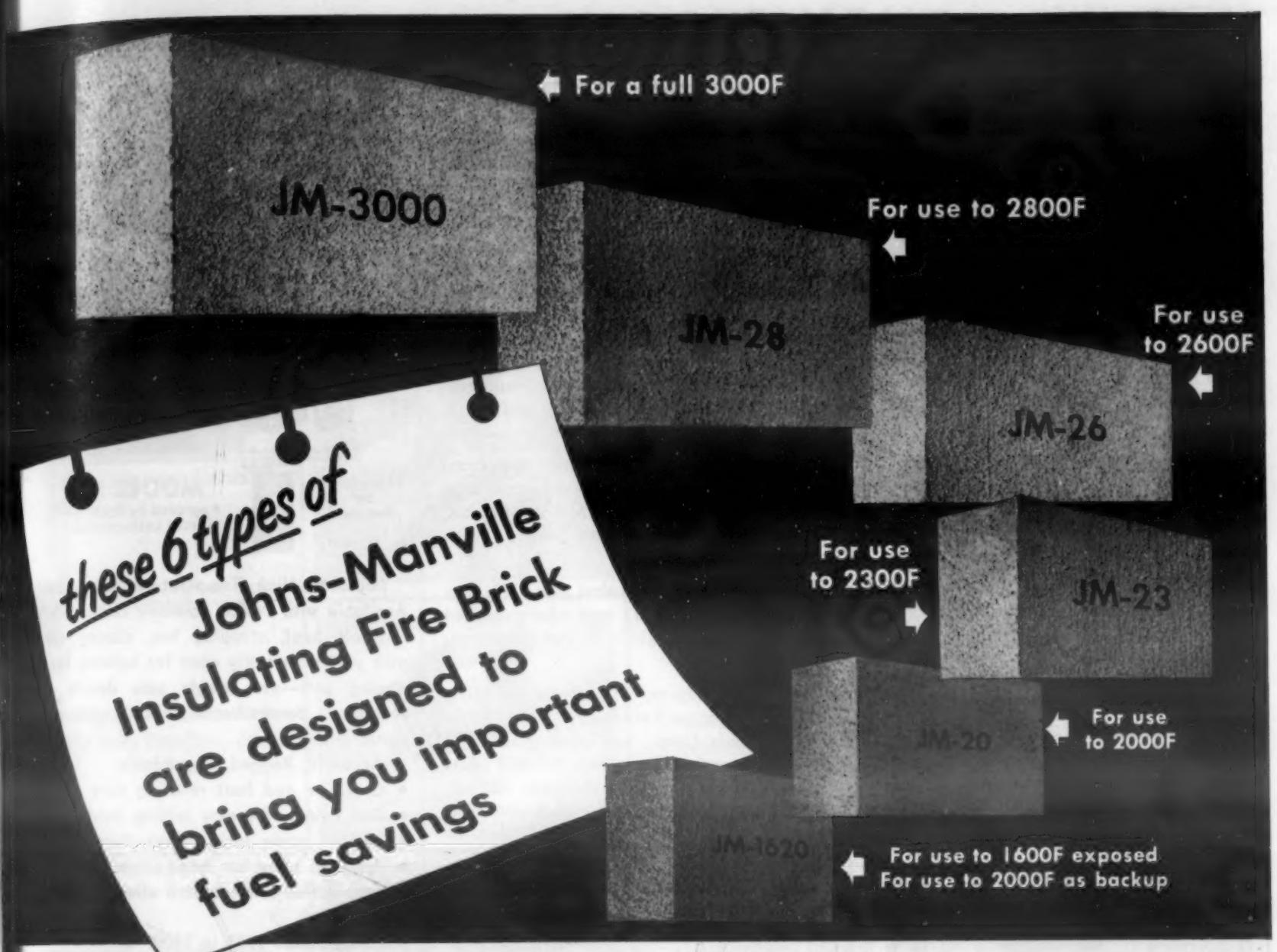
The first Doehler Award of the American Die Casting Institute was presented to *C. R. Maxon,* of the New Jersey Zinc Co., during the organization's annual meeting. The award was in acknowledgment of Mr. Maxon's "outstanding achievement contributing to the advancement of the die casting industry this year," which concerned his work with Federal agencies in the Canal Zone earlier in the year.

Malvern J. Gross has been appointed administrative assistant to Dr. Kenneth H. Kingdon, technical manager of the Knolls Atomic Power Laboratory. He formerly was vice president of the General Electric X-Ray Corp., in charge of engineering. It was also announced that *Robert Paxton,* manager of the Transformer & Allied Product Divs. of G.E.'s Apparatus Dept., was named manager of manufacturing policy, with headquarters in New York City and Schenectady. Mr. Paxton succeeds *Raymond R. Rausch,* vice president, who has resigned to return to the automotive industry.

Jessop Steel Co. has announced the appointment of *Frank B. Rackley,* executive vice president, to the position of president of the company. At the age of 33, he is the youngest president of a steel producing company in the United States.

Walter L. Havekotte has joined Firth Sterling Steel & Carbide Corp. as assistant manager of research. Prior to this new position, Mr. Havekotte had been research engineer for Battelle Memorial Institute.

Directors and officers of Rem-Cru Titanium, Inc., a new manufacturing company jointly owned by Remington Arms Co., Inc. and Crucible Steel Co. of America, have been announced. Chairman of the board of Rem-Cru is *C. K. Davis,* president and general manager of Remington. *W. H. Colvin, Jr.,* president of Crucible, was named president and a director. Other officers include: vice president and a director—*R. S. Poister,* Cru-



You can make important savings in fuel by taking advantage of the quick heating characteristics of J-M Insulating Fire Brick. These light-weight brick permit a quicker rise to proper operating temperature in the furnace because of their low heat storage capacity, and low thermal conductivity. Where furnaces are being intermittently operated these are two especially important characteristics.

These same insulating materials can also be obtained in large size units called Johns-Manville Insulating *Fireblok*. This product has many advantages over the smaller size fire brick for certain types of jobs . . . from both a construction and stability standpoint. The Fireblok units can be quickly applied because they are easy to cut and fit. Fireblok insulations provide additional heat savings because they reduce the number of joints, and require less mortar for bonding.

It will pay you to let a Johns-Manville insulation engineer explain the many ways in which you can save by using these insulations in your furnaces. Just write for further information to Johns-Manville, Box 290, New York 16, N. Y.

JOHNS-MANVILLE JM PRODUCTS

	JM-1620	JM-20	JM-23	JM-26	JM-28	JM-3000
Densities, lb per cu ft	29	35	42	48	58	63-67
Transverse Strengths, psi	60	80	120	125	120	200
Cold Crushing Strengths, psi	70	115	170	190	150	400
Linear Shrinkage†, percent	0.0 at 2000 F	0.0 at 2000 F	0.3 at 2300 F	1.0 at 2600 F	4.0 at 2800 F	0.8 at 3000 F
Reversible Thermal Expansion, percent	0.5—0.6 at 2000 F †	0.5—0.6 at 2000 F	0.5—0.6 at 2,000 F	0.5—0.6 at 2000 F	0.5—0.6 at 2000 F	0.5—0.6 at 2000 F
Conductivity* at Mean Temperatures						
500 F	0.77	0.97	1.51	1.92	2.00	3.10
1000 F	1.02	1.22	1.91	2.22	2.50	3.20
1500 F	1.27	1.47	2.31	2.52	3.00	3.35
2000 F	—	1.72	2.70	2.82	3.50	3.60
Recommended Service						
Back up	2000 F	2000 F	2300 F	2600 F	2800 F	3000 F
Exposed	1600 F	2000 F	2300 F	2600 F	2800 F	3000 F

†24-hr. simulative service panel test for JM-3000; 24-hr. soaking period for other brick.

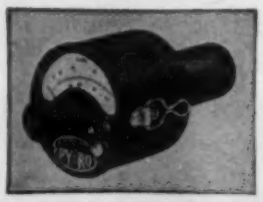
*Conductivity is expressed in Btu in. per sq ft per F per hour of the designated mean temperatures.

Note: Above tests are in accordance with A.S.T.M. tentative standards.

Johns-Manville *first in* INSULATIONS

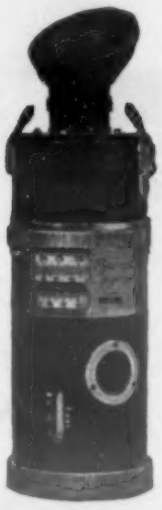
WHY GUESS THE TEMPERATURE . . . When you can SEE it!

PYRO
Radiation Pyrometer

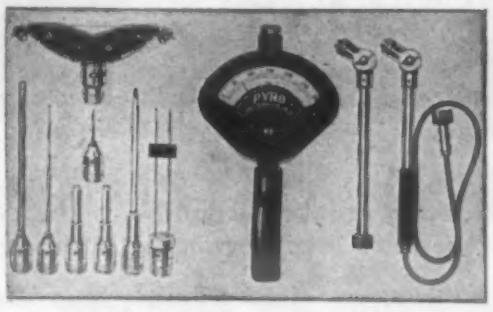


Tells spot temperatures instantly in heat-treating furnaces, kilns forgings and fire boxes. No thermocouples, lead wires or accessories needed! Temperature indicated on direct-reading dial at a press of the button. Any operator can use it. Two double-ranges for all plant needs. Write for FREE Catalog No. 100.

PYRO
Optical Pyrometer

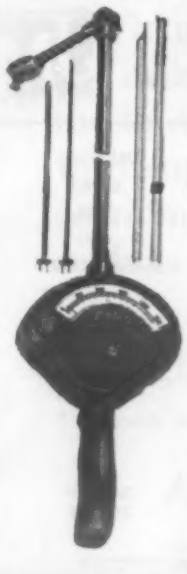


Determines temperatures of minute spots, fast-moving objects and smallest streams — at a glance! No correction charts or accessories needed. Easy to use—weighs only 3 lbs. Special types available to show true spout and pouring temps. of molten ferrous metal measured in open. Five temp. ranges. Write for FREE Catalog No. 80.



EIGHT INSTRUMENTS ALL IN ONE

The NEW PYRO Surface Pyrometer handles all surface temperature measuring jobs. Has 8 types of thermocouples; all interchangeable in seconds with no recalibration or adjustment. Automatic cold end compensator, shock, moisture and dust proof. Accurate, big 4¾" indicator. Available in 5 temperature ranges. Get FREE Catalogue No. 160.



BETTER TEMPERATURE CONTROL FOR NON-FERROUS FOUNDRIES

The Pyro Immersion Pyrometer is shock proof, moisture proof, dust proof, immune to magnetic influences. Shielded steel housing. Instantly interchangeable thermocouples without adjustment or recalibration. Large 4" scale. Equipped with exclusive Lock Swivel. Ranges 0-1500 and 0-2500 F. Get FREE Catalogue No. 150.

THE PYROMETER INSTRUMENT CO.
New Plant & Laboratory
BERGENFIELD 27, NEW JERSEY
Manufacturers of Pyro Optical, Radiation Immersion and Surface Pyrometers for over 25 years.

News Digest

cible vice president in charge of operations; vice president, treasurer and a director—*W. U. Reisinger,* Remington vice president and treasurer; vice president—*W. F. H. Mattlage,* Remington director of production; secretary—*K. R. Vogel,* secretary of Crucible; and directors—*M. R. Warden,* vice president and assistant general manager of Remington; and *L. L. Ferrall,* Crucible director of metallurgy.

Walter V. Ronner has been appointed to the post of director of industrial relations for the Lewyt Corp. Mr. Ronner had previously held the same position with Revlon Products Corp.

The election of Admiral *Jonas H. Ingram,* U.S.N. (retired) as a vice president of Reynolds Metals Co. has been announced.

D. Gray Weaver, formerly in the Product Development Laboratory of the Acheson Colloids Corp., has been transferred to the Newark office, where he will assist in the co-ordinating of technical and research problems involving Acheson Colloids Corp. and Acheson Colloids, Ltd. of London.

Vanadium Corp. of America has named *Howard H. Wilder* manager of its Iron Foundry Div., with headquarters in Detroit. Mr. Wilder previously served as chief metallurgist of the Foundry Div. of the Eaton Manufacturing Co.

Ivan E. Howard, hydraulics and lubrication engineer, has been appointed regional supervisor of the Industrial Truck Div. of the Clark Equipment Co. in the South Central territories. His headquarters will be in Peoria, Ill.

The American Bridge Co. has awarded the Gary Medal to *George E. Howe,* designing engineer, and *T. A. Foster,* chief clerk, for 50 years of continuous service with this United States Steel Corp. subsidiary.

James F. Stomber has joined The Hanson-Van Winkle-Munning Co. as administrative assistant. He formerly served as assistant to the vice president and comptroller of the Lee Higginson Corp.

Westinghouse Electric Corp. has awarded Benjamin Garver Lamme scholarships to two of its engineers—*E. A. DeZubay,* research engineer at the Westinghouse Research Laboratories; and *G. W. Hardigg,* design engineer in the Company's Aviation Gas Turbine Div. Each scholarship is valued at $2500 plus traveling expenses, and is to be applied toward full-time graduate study at an accredited university either here or abroad.

Richard W. Webster has joined John W. Masury & Son, Inc. as a consultant.

The International Nickel Co., Inc. has

BURLING
TEMPERATURE LIMIT SWITCHES
USE NO LIQUIDS . . . NO GASES

Literature on Request

MODEL H
Approved by Factory Mutual Laboratories

Improved High Temperature Safety Switch. Available with switch normally closed for cutting off heat, stopping fan, closing valve—with switch normally open for lighting lamp or ringing bell—with single pole double throw switch . . . breaks heating circuit while closing alarm circuit.

- Accurate, Rugged, Dependable
- Corrosion and heat resisting tube
- Dial Pointer for easy setting inside case
- Locking screw locks temperature setting.
- Terminal plate has large screw terminals
- Snap-action Micro-Switch eliminates contact troubles
- Range minus 100° to 1400° F. Adjustable range 200 degrees
- Dimensions—5⅛" x 1¾" x 3"

MODEL V-I

For lower temperature range from 0-300°F. Available for minimum of —100° to maximum of 600°F. Usual adjustable range 50-150°, operating differential may be as small as ±¼ or as large as ±5°. Adjustable by screw and dial inside case. (Sizes 2¾" diameter × 4¼" high.)

MODEL D

Adjustable range 200-500°F. Temperature range 0-1400°F. For use where temperature must be changed to suit operating conditions. Turn outside knob to change temperature setting. (Sizes 5½ x 2¾ x 2¾".)

Instruments also Built to Specifications

Making Precision Controls for Over 12 Years

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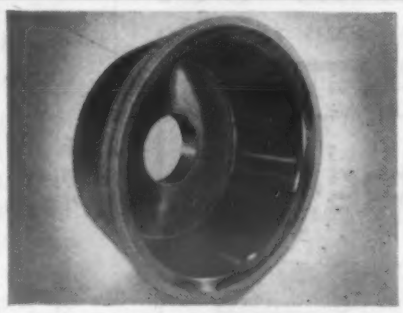
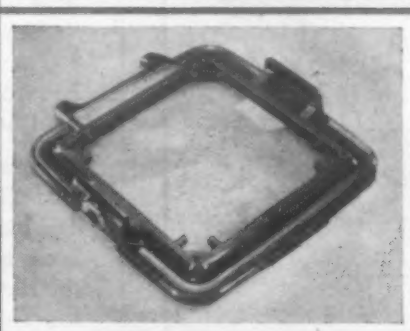
HOW TO CHOOSE YOUR
HEAT RESISTANT GRADE
PHENOLIC MOLDING COMPOUND

What do you make?		Properties you need	DURITE recommends
Heater plugs and similar appliance parts.		Excellent finish and resistance to heat and moisture, improved impact strength.	For general use: 533 For highest heat resistance and impact strength: 577 Black or brown.
Cooking utensil handles, electric iron handles, etc.		Lustrous finish, good heat and moisture resistance.	For improved heat resistance: 509 For good heat resistance with higher impact: 533 For general use: 560 Black or brown.
Diamond wheel cores and similar industrial applications.		Improved impact coupled with good heat resistance.	Improved impact: 577 Black. Highest heat resistance: 739 Black or brown.
Electric waffle base, toaster bases, etc.		Lustrous finish, good heat and moisture resistance.	For general use: 560 For improved heat resistance: 509 For improved heat resistance with higher impact: 533 Black or brown.
Heavy duty switches.		Good heat and moisture resistance with good impact properties.	For general use: 739 Black or brown. For improved impact: 577 Black.

FREE! Write for catalog, fully describing the wide range of DURITE phenolics for General Purpose, Heat Resistance, Electrical Resistance, Impact Resistance—and made-to-order Modifications of standard materials embodying special characteristics to meet your specific requirements. Address:

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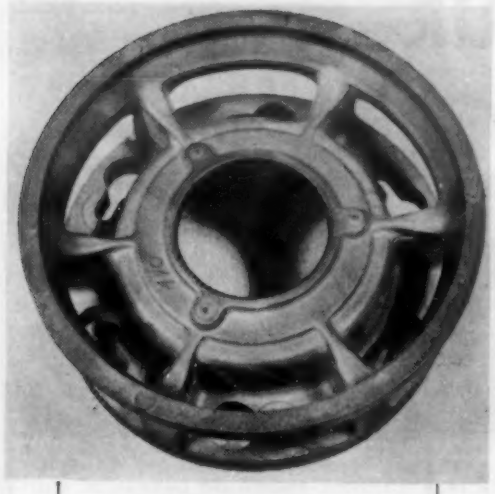
Molding Powders • Bonding Resins • Cements



Mounting Flange Bracket
For Westinghouse Generator
Using 410 Stainless

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PRECISION CASTINGS

Booking dies and frozen mercury patterns assure you of

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- ACCURACY
- CLOSE TOLERANCES
- 60-80 MICRO FINISH
- MINIMUM MACHINING

BOOKING DIES
The big plus in PRECISION CASTINGS

Intricate one-piece castings weighing up to 40 lbs. All ferrous and non-ferrous metals.

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EAST 45th ST. AND HAMILTON AVE. • CLEVELAND 14, OHIO

Send for this BROCHURE today!

Gives Technical Specifications

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A Brief Survey of
TECHNICAL CHARACTERISTICS
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MOLDED CERAMIC PRODUCTS

for
Electrical Wiring
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Special Applications

Prepared by the Technical Staff of the
STAR PORCELAIN COMPANY, Trenton, N. J.

15-page illustrated booklet describes a wide variety of moulded ceramic compositions; technical specifications can be readily adapted to solve your materiel problems.

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MUIRHEAD AND JAY AVES. TRENTON, N. J

News Digest

announced the sudden death of *Harold ... Arnold,* technical assistant to the presid... of Inco.

Charles N. Safford, president and di... rector of the Lovejoy Tool Co., died sud... denly in Burlington, Vt.

News of Companies

The *Remington Arms Co., Inc.,* Bridg... port, Conn., and *Crucible Steel Co. ... America,* New York City, have announced the formation of a jointly-owned compan... *Rem-Cru Titanium, Inc.,* which will pro... duce titanium metal and titanium alle... products. Headquarters for Rem-Cru wil... be established in the Pittsburgh, Pa. area but sales and research activities are being handled from the Bridgeport offices of Remington for the time being. C. ... Bradford, who has been in charge of titanium sales, pilot production and gen... eral development for Remington, was named director of operations of the new company.

Purchase of a plant in Bowling Green, Ky., by *Westinghouse Electric Corp.,* Pittsburgh 30, Pa., has been announced. This new plant, expected to be in operation by the end of the year, will almost double the flashbulb production facilities of Westinghouse.

Flexible Tubing Corp. will move Nov. 15, 1950 from its present location in Branford, Conn., to a new plant on Whitfield St. in Guilford, Conn.

Plans to consolidate the operations of *The Baldwin Locomotive Works,* Philadelphia, and *Lima-Hamilton Corp.* have been announced. The proposed name of the new company is *Baldwin-Lima-Hamilton Corp.*

A new unit of a plastics plant near Parkersburg, W. Va., owned by *E. I. du Pont de Nemours & Co. (Inc.),* Wilmington, Del., has entered into the commercial production of "Teflon" tetrafluoroethylene resin, an industrial plastic highly resistant to chemicals and heat.

A new plant for the production of electrolytic chromium is going to be constructed at Sault Ste. Marie, Mich., by the *Electro Metallurgical Div., Union Carbide & Carbon Corp.,* New York 17. The plant is expected to be in operation in the Spring of 1951.

Hy-Pro Tool Co., a subsidiary of *Continental Screw Co.,* is now completely established in a new plant adjoining Continental Screw in New Bedford, Mass., and full capacity operation has been reached. At the same time, Hy-Pro an-

a cyclone was the hit of the show!

Back in '35 at the Amphitheatre in Chicago, Lindberg's CYCLONE Furnace was the hit of the show . . . because it brought to every heat treater a *new and better way to do his job!* The CYCLONE Furnace—our first product, was the first practical 100% forced convection furnace. It represents a basic improvement in existing equipment—it has never been successfully imitated.

Through the years we have grown in size and in the scope of the products we produce. We will have the products of eight divisions on display at this year's show—many of these products representing basic improvements in the tools of your trade.

on display:

HEAT TREATING FURNACES
MELTING FURNACES
HIGH FREQUENCY EQUIPMENT
ELECTRICAL EQUIPMENT
LABORATORY EQUIPMENT
AIR & HYDRAULIC EQUIPMENT
FABRICATION
AUTO ACCESSORIES

Be sure to see our exhibit—Booth #1204—National Metal Congress, Amphitheatre, Chicago, October 23—27, 1950

LINDBERG ENGINEERING COMPANY

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ENGELHARD

meets every

THERMOCOUPLE NEED!

Noble Metal Thermoelements and Thimbles

platinum vs. platinum-rhodium—repaired at substantial savings, with credit for reclaimed metal.

Base Metal Thermoelements

chromel vs. alumel iron vs. constantan copper vs. constantan

Standard Insulators

All types and sizes

Primary and Secondary Protection Tubes

Terminal Heads and Lead Wire, etc.

At Engelhard, you will find a complete line of thermocouples and accessories to meet all requirements. The individual parts of Engelhard thermocouples are selected and assembled for your specific conditions of atmosphere and temperature. You can rely on Engelhard's more than 40 years of research and instrument-building experience to solve your temperature measurement problems. Write for complete information today.

CHARLES ENGELHARD, INC.

850 PASSAIC AVE., EAST NEWARK, N. J.

News Digest

nounced the appointment of *Arthur B. Hagan & Associates,* Chicago, as a direct factory representative.

Expansion of operations has caused *The National Radiator Co.,* Johnstown, Pa., to begin construction of a new sheet metal plant in Altoona, Pa. It is scheduled for completion in December, and should be in operation the first of the year.

Hooker-Detrex, Inc. has announced the completion of a large trichlorethylene plant at Ashtabula, Ohio, which will be utilized in the manufacture of Perm-A-Clor and Triad metal degreasing solvents for the *Detrex Corp.,* Detroit 32. Full production capacity is expected to be reached by Nov. 1, 1950.

Formation of a Product Engineering Dept. has been announced by the *Atlantic Steel Co.,* Atlanta 1, Ga. F. A. Teeple, Jr. was named manager of the department, and his staff of metallurgical and product engineers is composed of Fred O. Reese, Emmett R. Rushin, Lawrence A. Wallace and Michael F. Wiedl, Jr.

International Harvester Co. has put into operation the first unit of its new research foundry located in the company's manufacturing research building at 5225 S. Western Blvd., Chicago. G. P. Phillips became general supervisor of foundry research, and A. W. Anderson assistant general supervisor. The second unit is now being established, and is expected to be completed during the next year.

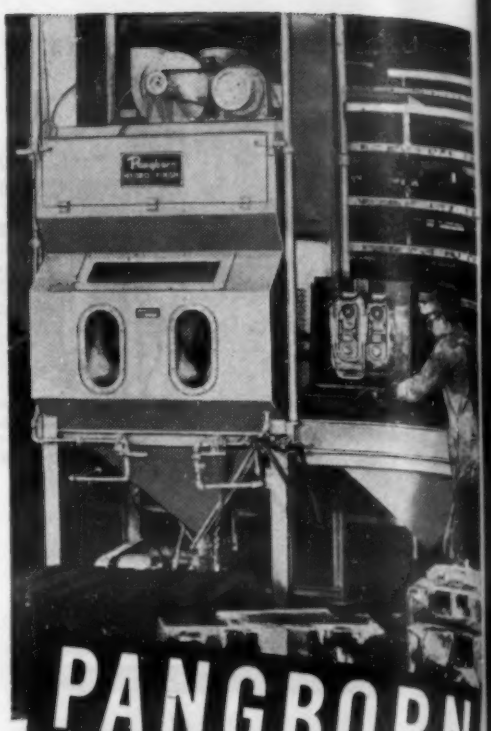
The assets of the Engine Div. of the *Atlas Imperial Diesel Engine Co.,* Oakland, Calif., have been purchased by *The National Supply Co.,* Pittsburgh, Pa. Production of Atlas Imperial engines and service parts will be transferred to National's Superior Engine Div. in Springfield, Ohio, as rapidly as possible.

John A. Roebling's Sons Co., Trenton 2, N. J., has appointed *A. B. Murray Co., Inc.,* Elizabeth, N. J., as their agent for Blue Center wire rope, wire rope slings and wire rope fittings.

A new plant for the manufacture of all types of ingot molds and accessories is being erected between 167th St. and the Calumet River in Lansing, Ill. by the *Vulcan Mold & Iron Co.,* Latrobe, Pa. Completion date is scheduled for Apr. 1, 1951, and the new plant will be known as the *Chicago Div.* of Vulcan.

Koiled Kords, Inc., New Haven, Conn., has appointed *R. D. Fleck & Co., Ltd.,* Oshawa, Ont., exclusive distributor in Canada for all types of Koiled Kords.

A jointly-owned company and plant has been put into operation in Cleveland by the *Republic Steel Corp.* Cleveland 1, and *Henry L. Crowley & Co., Inc.,* West Orange, N. J. Known as the *Crowley-Republic Corp.,* this new plant will sup-



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HYDRO-FINISH increases die life for Rockford Drop Forge by eliminating surface-disturbing emery cleaning at end of runs. Hand polishing is cut to a minimum because it's done *before* heat treating. Hydro-Finish removes all heat-treat scale, holds tolerances and leaves surface smoother than hand polishing. Estimates show Hydro-Finish will pay for itself out of savings in two to three years!

HYDRO-FINISH simplifies manufacture and maintenance of tools, dies and molds. Costly hand work is reduced and surfaces are virtually free from directional grinding lines. Hydro-Finish assures better bonding, electroplating, painting—gives you *the surface you want* within .0001"!

FOR FULL INFORMATION visit our Booth No. 2560, NATIONAL METAL CONGRESS AND EXPOSITION, Chicago, Ill. (Oct. 23-27), or write for Bulletin 1400A to: PANGBORN CORPORATION, 1700 Pangborn Blvd., Hagerstown, Maryland.

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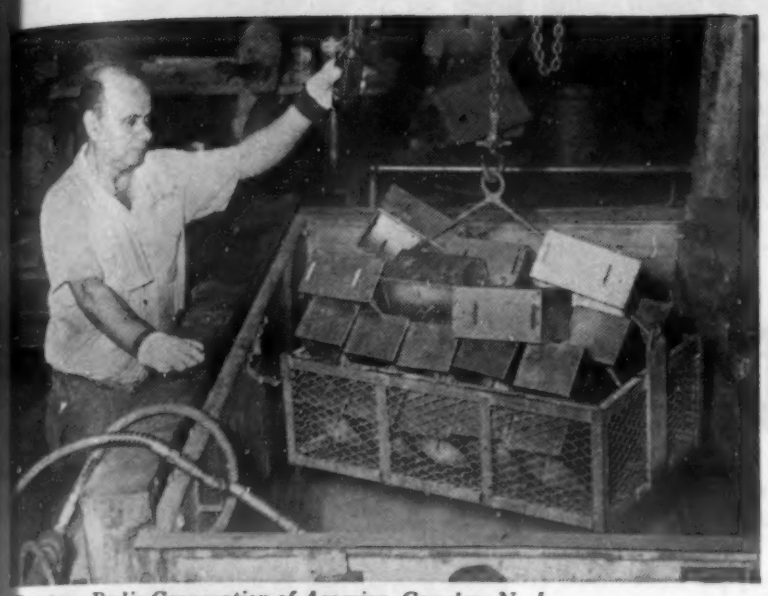
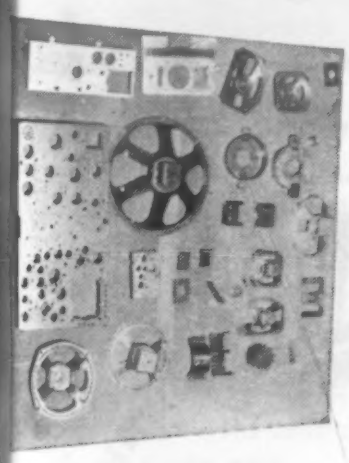
RCA speeds production, cuts cleaning costs on a wide range of metal parts . . . with



Courtesy: *Radio Corporation of America, Camden, N. J.*

VAPOR DEGREASING

From fabricated steel racks . . . to aluminum microphone castings . . . all kinds of parts made of all types of metals are cleaned quickly and economically by vapor degreasing in the Camden plant of the Radio Corporation of America.



In 1940, RCA replaced the hand cleaning of its electronic equipment parts with this speedy modern method. The trichlorethylene solvent, supplied by equipment manufacturers under various trade marks, has proved highly efficient in the removal of oil, dirt, and grease from even the most intricate parts. The work is degreased before and after machining and finishing . . . is delivered clean and dry, ready for inspection or further processing. As a result, RCA has been able to speed up production, yet hold down its cleaning costs.

The increased production and reduced operating time realized at RCA may indicate the possibility of more efficient cleaning with vapor degreasing in your plant. An investigation of this rapid, thorough and economical method will prove to you why it is being used by thousands of plants to clean work ranging from watch springs to machine housings.

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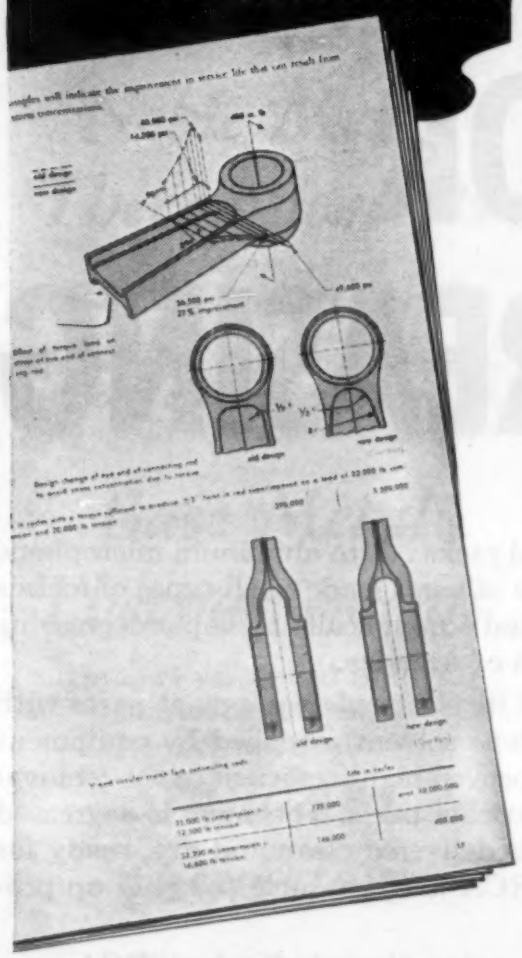

How to avoid the localized stresses which start failure is a basic problem of design. This 72 page booklet analyzes many good and bad features of design. It also deals with problems of steel selection and treatment from the viewpoint of the design engineer —instead of the metallurgist.

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News Digest

plement the production of "Croloy" at the West Orange facilities.

American Anode, Inc., Akron, Ohio, has purchased the *Wayne Knitting Mills* plant at Riverside, N. J. Present facilities will be increased to manufacture latex products, with full production expected by June 1951.

News of Societies

The *Resistance Welder Manufacturers Assn.* has moved its headquarters from 505 Arch St. to a larger building located at 1900 Arch St., Philadelphia 3.

The 19th National Exposition of Power and Mechanical Engineering will be held in Grand Central Palace, New York City, from Nov. 27 to Dec. 2, 1950. For the first time, the Exposition will be conducted under the auspices of the *American Society of Mechanical Engineers,* in conjunction with the Society's annual meeting at that time.

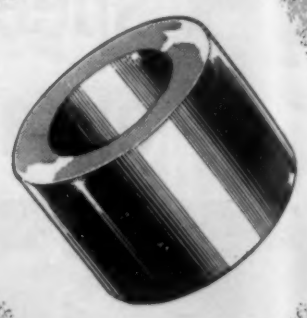
The Illinois Institute of Technology has added two new members to its staff. Dr. William Rostoker, a lecturer at the University of Birmingham, England, was appointed an assistant professor of metallurgical engineering. And Charles H. Parcells, formerly a metallurgical assistant at the International Harvester Co., was named an instructor in metallurgical engineering.

The 10th International Heating and Ventilating Exposition, also known as the Air Conditioning Exposition, is scheduled to be held at the Commercial Museum in Philadelphia from Jan. 22 to 26, 1951. The display will be under the auspices of the *American Society of Heating & Ventilating Engineers,* in connection with the Society's 57th annual meeting.

Dr. Gustavus J. Esselen, vice president of the United States Testing Co., Inc., was recently elected vice president of the *Society of Chemical Industry,* which maintains its headquarters in London, England. Dr. Esselen will continue in his capacity as chairman of the American section of the Society, in addition to his new duties as vice president.

An exposition of modern laboratory equipment will be a feature of the 1951 Pittsburgh Conference on Analytical Chemistry & Applied Spectroscopy, to be held from Feb. 28 to Mar. 2 in Pittsburgh, Pa. The Conference is jointly sponsored by the Analytical Chemistry Group of the Pittsburgh Section of the *American Chemical Society* and the *Spectroscopy Society of Pittsburgh.*

WORKS WHERE OTHERS WON'T



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"Our magnesium chloride heat exchangers operate at 50 psi. and average temperatures of 180° F.," said a producer of magnesium. "The air-free solution is circulated at a velocity of 6½ feet a second. Our present equipment suffers from corrosion pitting and stress corrosion cracking."

INCO's Corrosion Engineering Service reviewed all reports on magnesium chloride which were contained in the Corrosion Data File.

A comprehensive summary of this information was sent to the producer. (He later requested additional copies for members of his staff.)

Space limitations make it impossible to give complete details of the summary here.* The principal conclusions drawn were:

1 Corrosion rate of Inconel in relatively air-free solutions of hot magnesium chloride will ordinarily be less than 1 mdd.

2 Inconel is usually not subject to pitting below the liquid level.

3 Inconel is not subject to stress corrosion cracking.

4 In air-free solution under vacuum, Monel showed a corrosion rate of 2 mdd.

5 Ni-Resist and 30% nickel cast iron have sufficient corrosion resistance to be useful materials for pumps and valves.

The producer installed Inconel equipment with considerable success.

**Copies of the full summary, exactly as furnished this producer, are available. If you'd like one, use the coupon at the right.*

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Meetings and Expositions

SOCIETY OF THE PLASTICS INDUSTRY, annual conference. Swampscott, Mass. Oct. 18-20, 1950.

ENGINEERS' COUNCIL FOR PROFESSIONAL DEVELOPMENT, annual meeting. Cleveland. Oct. 20-21, 1950.

AMERICAN MINING CONGRESS, metal and nonmetallic convention. Los Angeles. Oct. 22-24, 1950.

AMERICAN GEAR MANUFACTURERS ASSOCIATION, semi-annual meeting. Chicago. Oct. 23-25, 1950.

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS, Institute of Metals Div. fall meeting. Chicago. Oct. 23-25, 1950.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Fuels Div. conference. Cleveland. Oct. 23-25, 1950.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION, annual meeting. Houston, Tex. Oct. 23-26, 1950.

WIRE ASSOCIATION, annual convention. Baltimore, Md. Oct. 23-26, 1950.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, fall meeting. Oklahoma City, Okla. Oct. 23-27, 1950.

AMERICAN SOCIETY FOR METALS, annual meeting. Chicago, Oct. 23-27, 1950.

AMERICAN WELDING SOCIETY, annual meeting. Chicago. Oct. 23-27, 1950.

NATIONAL METAL CONGRESS. Chicago. Oct. 23-27, 1950.

SOCIETY FOR NON-DESTRUCTIVE TESTING, annual meeting. Chicago. Oct. 23-27, 1950.

NATIONAL TOOL & DIE MANUFACTURERS ASSOCIATION, annual meeting. Cleveland. Oct. 29-Nov. 1, 1950.

PORCELAIN ENAMEL INSTITUTE, annual meeting. White Sulphur Springs, W. Va. Nov. 1-2, 1950.

AMERICAN SOCIETY OF BODY ENGINEERS, annual meeting. Detroit. Nov. 1-3, 1950.

PITTSBURGH CONFERENCE ON X-RAY AND ELECTRON DIFFRACTION. Pittsburgh, Pa. Nov. 2-3, 1950.

SOCIETY OF AUTOMOTIVE ENGINEERS, diesel engine meeting. Chicago. Nov. 2-3, 1950.

MEEHANITE METAL INSTITUTE, annual meeting. Chicago. Nov. 8-11, 1950.

NATIONAL FOUNDRY ASSOCIATION, annual meeting. Chicago. Nov. 9-10, 1950.

SOCIETY OF AUTOMOTIVE ENGINEERS, fuels and lubricants meeting. Tulsa, Okla. Nov. 9-10, 1950.

STEEL FOUNDERS' SOCIETY OF AMERICA, annual technical and operating conference. Cleveland. Nov. 9-11, 1950.

AMERICAN PETROLEUM INSTITUTE, annual meeting. Los Angeles. Nov. 13-16, 1950.

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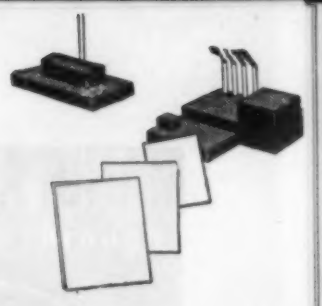

MANUFACTURERS' LITERATURE

Materials

Irons • Steels

Corrosion Resistant Steel. Bethlehem Steel Co., 52 pp., ill., No. 259. Properties and characteristics of Mayari R low alloy, light, strong steel with high corrosion resistance. (1)

High-Speed Steels. Climax Molybdenum Co. Reports indicate molybdenum high-speed steels, hardening at lower temperatures than tungsten tool grades, cut production costs. (2)

Tool Steel Selector. Crucible Steel Co. of America. Selects tool steel for desired application. Indicates type steel, hardening depth and heat treating information. (3)

Alloy Mold and Die Plate. W. J. Holliday & Co., 4 pp., ill., No. 905. Uses of Speed Alloy, deep-hardening, strong and machinable alloy steel plate for molds and dies. (4)

Stainless-Clad Steel. Ingersoll Div. of Borg-Warner Corp. Folder describes IngAclad, 20% cladding of stainless steel bonded to backing of carbon steel. (5)

High-Strength, Low-Alloy Steel. Jones & Laughlin Steel Corp., 32 pp., ill. Complete data on Otiscoloy, widely used in the transportation industry. (6)

Clad Steels. Lukens Steel Co., 68 pp., ill. Compositions, properties, corrosion ratings and applications of nickel-clad, stainless-clad, Inconel-clad and Monel-clad steels. (7)

Screw Steel. Joseph T. Ryerson & Son, Inc., 2 pp. Describes Ledloy, lead bearing steel claimed to machine 30 to 50% faster than the fastest cutting screw steel previously available. (8)

Low Alloy and Stainless Steels. Sharon Steel Corp., 4 pp., ill., No. 1a/26. Details of this company's stainless steels. High-tensile low alloy steels, Cor-Ten and N-A-X also covered. (9)

Non-Slip Steel Plate. Alan Wood Steel Co., 8 pp., ill. Specifications and characteristics of Algrip abrasive-rolled steel floor plate designed for non-skid applications. (10)

Nonferrous Metals

Continuous-Cast Bronze. American Smelting & Refining Co., 12 pp., ill. Applications, physical properties and specifications of continuous-cast bronze rods, tubes and shapes. Includes tables and charts. (11)

Aluminum-Bronze Alloys. Ampco Metal, Inc. Gives physical properties of aluminum-bronze alloys providing high "strength to weight" ratio and good resistance to wear and corrosion. (12)

Thermostatic Bimetal. W. M. Chace Co., 4 pp., ill., No. 1a/10. Properties of thermostatic bimetals and detailed formulae used in their application to temperature responsive devices. (13)

Aluminum Bronze. Dirilyte Co. of America, Inc., 12 pp., ill. Physical properties and specifications of Molin Metal, pure aluminum bronze for quality castings. (14)

Magnesium. Dow Chemical Co., 8 pp., ill. *Magnesium Topics,* Vol. 1, No. 4. Articles on extrusion of powdered magnesium alloys and sand casting magnesium. (15)

Spring Alloy. Elgin National Watch Co., Industrial Products Div., 2 pp. Composition and properties of Elgiloy, cobalt-chromium-base spring alloy. (16)

Nickel Alloy Corrosion Resistance. The International Nickel Co., Inc., 16 pp., ill., reprint. Corrosion resistance of nickel, Monel and Inconel to soap and fatty acids as compared to other metals. (17)

Aluminum. Reynolds Metals Co., Aluminum Div., 10 pp., ill. Aluminum fabrication and finishing information; available forms, their alloys, tempers and sizes; and alloy properties and applications. (18)

Nonmetallic Materials • Parts

Molded Soft Rubber. Acushnet Process Co., 32 pp., ill., No. 50. Describes facilities for making and developing a wide variety of custom precision molded soft rubber parts. (19)

Felt Parts. American Felt Co., folder, ill. Describes custom-made cut felt parts with applications, including separating, protecting, sealing, polishing and insulating. (20)

Hard Rubber and Plastics. American Hard Rubber Co., 60 pp. Manual gives detailed selection data on hard rubber and plastics materials. (21)

To obtain literature appearing on these pages, please refer to easy-to-use reply card on page 165.

Foundry Sand Resin Binders. Bakelite Div., Union Carbide & Carbon Corp., 16 pp., ill., No. J-685. Shows use of Bakelite resin binders in Croning Process for making foundry molds and cores. (22)

Plastics. Continental-Diamond Fibre Co., 30 pp., ill. Properties, forms, applications and fabricating procedures of Dilecto and Celoron thermosetting plastics. (23)

Plywood. Douglas Fir Plywood Assn., 32 pp., ill. Series of articles shows how to use plywood effectively in fixtures, displays, posters and signs. (24)

Silicone Compound. Dow Corning Corp., 4 pp., ill. Data on D.C. Antifoam A, silicone compound for killing foam in aqueous solutions. Typical applications included. (25)

Inert Resin. E. I. du Pont de Nemours & Co., Inc., 12 pp., ill. Description, physical properties and uses of "Teflon," highly inert resin useful for gaskets and packings. (26)

Plastics News. Durez Plastics & Chemicals, Inc. Monthly *Durez Plastics News* presents many ideas and applications for plastics users. (27)

Flexible Tubing. Flexible Tubing Corp., 8 pp., ill., No. 5-4. Applications and performance data on Spiratube, flexible tubing for ventilation and materials conveying. (28)

Plastics. General Electric Co., Plastics Div., 16 pp., ill., No. 1b/13. Characteristics, uses and properties of various molded and laminated plastics of this company. (29)

Rubber. B. F. Goodrich Chemical Co. Properties and applications of Hycar, high strength compression and heat resistant rubber suited to heavy duty service. (30)

Cellulosic Plastics. Hercules Powder Co. Describes cellulosic plastics, their properties and applications, and this company's design and technical facilities for developing plastic products. (31)

Hardboards. Masonite Corp., 24 pp., ill., No. 1d/2. Properties and advantages of Preswood and other Masonite hardboards, and their relation to product design. (32)

Plastic Pipes and Fittings. Elmer E. Mills Corp., 4 pp., ill. Properties of Mills-Plastic corrosion resistant pipes and fittings, made for wide usage in industry. (33)

Carbon Products. Morganite, Inc., 8 pp., ill., No. 1f. Specifications of various carbon bearings and bushings. Also, properties of six series of Morganite carbon products. (34)

Alkyd Molding Compound. Plaskon Div.,

MANUFACTURERS' LITERATURE

Libbey-Owens-Ford Glass Co., 16 pp., ill., No. 7131. Properties and molding characteristics of Plaskon Alkyd fast-molding compound. (35)

Hose, Molded Parts. Resistoflex Corp., 4 pp., ill., No. 4g/3. Properties and uses of this company's resinous-lined, reinforced industrial hose and custom-molded parts. (36)

Plastics Forms. Rogers Corp., 12 pp., ill. Describes two series of molded forms, which include molding boards, laminated sheets and punchings, and pre-shaped preforms. (37)

Inorganic Plastic Moldings. Rostone Corp., 6 pp., ill., No. 100. General characteristics of Rosite inorganic plastic moldings recommended for electrical insulation. (38)

Sponge Rubber. Sponge Rubber Products Co., 12 pp., ill. Specifications and descriptions of Spongex products, including sheet sponge rubber, die cut shapes, cord and strips. (39)

Molded Ceramics. Star Porcelain Co. Gives technical data on characteristics of molded ceramic products for electrical wiring, electrical heating and special purposes. (40)

Ceramic. Stupakoff Ceramic & Mfg. Co., 4 pp., No. 849. Properties of Stupalith, a new ceramic said to be unsurpassed in thermal shock resistance. (41)

Carbon-Graphite Parts. U. S. Graphite Co., 68 pp., ill., No. G-49. Detailed description of Graphitar, giving properties, chemical resistance, limitations, assembly information, design aids and 60 applications. (42)

Plastic Laminated Tubing. U. S. Plywood Corp., Plastics Div., 4 pp., ill. Types, properties and applications of Glasweld plastic laminated tubing. Tables of properties and bursting strengths. (43)

Polyvinyl Resins. U. S. Rubber Co., Naugatuck Chemical Div., 20 pp., ill. Properties, ingredients, compounding and processing of Marvinol polyvinyl chloride resins discussed in detail. (44)

Felt. Western Felt Works, 32 pp., ill. History of manufacture and uses of felt, including brief description of present-day methods and applications. (45)

Micarta. Westinghouse Electric Corp., 36 pp., ill. Properties, applications and advantages of Micarta industrial plastic given with selection tables for molded and laminated Micarta. (46)

Metal Parts • Forms

Aluminum Die Castings. Aluminum Co. of America. Book contains detailed technical information for effective design of aluminum die castings. (47)

Aluminum Extrusions. Aluminum Co. of America. Design potentials of extrusion process and cost savings in fabrication and assembly of extrusions are explained. (48)

Aluminum Parts. Aluminum Goods Mfg. Co., 56 pp., ill. Catalog covers extensive production facilities and technical services for producing wide range of parts. (49)

Die Pressed Forgings. American Brass Co., No. B-9. Details on applications and procedure of die press forging dimensionally accurate parts requiring less finishing. (50)

Certified Zinc Die Castings. American Die Casting Institute, Inc. Describes Certified Zinc Alloy Plan wherein member companies are guaranteed to produce "on grade" alloy die castings. (51)

Plated Metal Parts. American Nickeloid Co., ill. Indicates wide variety of economies available to users of pre-plated metals for parts manufacture. (52)

Nonferrous Plaster Mold Castings. Atlantic Casting & Engineering Corp., No. 4. Describes production of copper-base and aluminum alloy "Atlanticastings." (53)

Magnesium Parts. Brooks & Perkins, Inc. Folder includes tabulated characteristics of magnesium alloys, design data and typical B & P products. (54)

Steel Tubing. Bundy Tubing Co., 20 pp., ill. Properties, specifications and typical parts of Bundyweld double-walled, copper-coated steel tubing. (55)

Stainless Tubing. Carpenter Steel Co., Alloy Tube Div., 4 pp., ill. Physical properties, corrosion resistance and available sizes of this company's stainless steel tubing. (56)

Powdered Metal Parts. Chicago Powdered Metal Products Co., 4 pp., ill. Materials and advantages of Camet custom-molded powdered metal parts. Includes design tips. (57)

Stainless Fittings. The Cooper Alloy Foundry Co., 47 pp., ill. Catalog of wide assortment of stainless steel valves, fittings and accessories. Includes properties and analyses of Cooper alloys. (58)

Magnesium Die Castings. Doehler-Jarvis Corp., 4 pp., ill. Physical properties, applications and advantages of Doler-Mag magnesium die castings. (59)

Die Cast Parts. The Electric Auto-Lite Co., Die Casting Div., 16 pp., ill., No. G137. Describes facilities for making quality die castings using economical, advanced methods. (60)

Chromium-Nickel Castings. Electro-Alloys Div., American Brake Shoe Co., 60 pp. Properties, specifications and applications of cast 16 chromium-35% nickel alloys. (61)

Investment Castings. Engineered Precision Casting Co., 4 pp., ill. Describes Epco precision investment castings. (62)

Self-Lubricating Bushings. Graphite Metallizing Corp., 8 pp., ill., No. 108. Data on Graphalloy self-lubricating bushing includes characteristics, uses, clearances and materials selection. (63)

Precision Castings. Gray-Syracuse, Inc., 4 pp., ill. Various parts of precision-cast brass, bronze, beryllium, copper and steel. (64)

Permanent Magnets. Indiana Steel Products Co., 34 pp., *Permanent Magnet Manual* No. 3. Uses, types and materials of permanent magnets. Design data included. (65)

Aluminum Cable. Kaiser Aluminum & Chemical Corp. Details on properties of Kaiser Aluminum ACSR and All-Aluminum Cable. Tables of available reel sizes given. (66)

Aluminum Extruded Shapes. Light Metals Corp., 6 pp., ill. Shows facilities for producing to order a variety of indicated aluminum fabrications and extruded shapes. (67)

Cold-Drawn Shapes and Shells. Linde Air Products Co., 2 pp. Types of available Prest-O-Lite cold-drawn shapes and shells with materials and dimensional ranges given. (68)

Die Castings. Litemetal Die Cast, Inc., 12 pp., ill. How to select best light metal for die casting. Shows facilities for producing light metal pressure die castings. (69)

Gray Iron Castings. Meehanite Metal Corp., 8 pp., ill., No. 30. One of a series of bulletins describing current uses of Meehanite castings. (70)

Tungsten Carbide Shapes. Metal Carbides Corp., No. 50-G. 1325 sizes of available standard solid tungsten carbide shapes, including blanks, bars, strips, rods, tubes and bushings. (71)

Precision Castings. Microcast Div., Austenal Laboratories, Inc., 16 pp., ill. Advantages, design factors and wide applications of Microcast precision castings. (72)

Heat, Corrosion Resistant Castings. National Alloy Steel Div., Blaw-Knox Co., 22 pp., ill., No. 2041. Describes typical heat and corrosion resistant castings and the alloys used. (73)

Zinc Alloy Die Castings. New Jersey Zinc Co., 28 pp., ill. Principal features, methods of production and applications of Zamak-3 and Zamak-5 zinc alloy die castings. (74)

Steel Tubing. Ohio Seamless Tube Co. Informative booklet describes many methods of fabricating and forging steel tubing. (75)

Stainless Steel Castings. The Ohio Steel Foundry Co., 4 pp., ill., No. FC-350. Shows numerous stainless castings manufactured. Includes specifications of Fahrite stainless grades. (76)

Bushings. Randall Graphite Bearings, Inc., 12 pp., ill., No. 100. Complete price list of bronze bushings and specially grooved bushings; specifications of bored and solid bronze bars. (77)

Steel Tubing. Republic Steel Corp., No. 22. Describes full range of sizes, gages and analyses of carbon and stainless steel Electrunite tubing for severe fabrication. (78)

Aluminum Extruded Shapes. Reynolds Metals Co., Louisville 1, Ky., 138 pp., ill., No. RMC-11. Detailed aid to designing with aluminum extrusions. Available from Reynolds only, when requested on company letterhead.

Stainless Steel Castings. The Stainless Foundry & Engineering Co., 4 pp., ill. Shows variety of stainless castings and includes helpful engineering data. (79)

MANUFACTURERS' LITERATURE

Powder Metal Test Specimens. Metal Powder Assn., 3 pp., No. 10-50T. Tentative standards for tension test specimens of pressed and sintered metal powders. (142)

Versatile Testing Machine. Tinius Olsen Testing Machine Co., No. 40. Data on the Olsen Super "L" testing machine with 50 to 1 spread of testing ranges. (143)

Temperature Controls. The Pyrometer Instrument Co., No. 150. Catalog shows Pyro Immersion Pyrometer, accurate instrument for nonferrous foundry temperature control. (144)

Thickness Measure. Sperry Products, Inc., 4 pp., ill., No. 3700. Describes Reflectogage, portable instrument for determining materials thicknesses from one side. (145)

Hardness Tester. Steel City Testing Machines, Inc., 2 pp., ill., No. PB-2-48-2M. Describes model KDR Brinell Testing Machine designed for rapid hardness testing. (146)

Plastics Tests. U. S. Testing Co., Inc., 2 pp. Price list of physical, chemical, microbiological and permanence tests available for plastics film, sheeting and coated fabrics. (147)

Temperature Controls. Wheelco Instruments Co., 4 pp., ill., *Wheelco Comments,* Vol. 9, No. 3. Use of temperature control instruments to increase capacity of wire patenting process. (148)

General

Sensitized Materials. Eastman Kodak Co., Industrial Photographic Div. Booklet describes sensitized emulsions useful for scientific and industrial laboratory work. (149)

Temperature Controls. Claud S. Gordon Co., 4 pp., ill. Data on specifications and advantages of Xactline indicating and recording temperature controls. (150)

Corrosion Resistance Computer. The H. M. Harper Co. Enables quick determination of proper metal alloys for use with 143 different corrosive agents. (151)

Industrial Carburetor. C. M. Kemp Mfg. Co., 12 pp., ill., No. 1C-22. Capacity and dilution charts and specifications of Kemp Series "S" industrial carburetor. (152)

Wire Straightening and Cutting Machines. Mettler Machine Tool, Inc., 4 pp., ill. Operating instructions for, and advantages of five types of Shuster wire straightening and cutting machines. (153)

Vacuum Cleaner. The Spencer Turbine Co., 20 pp., ill., No. 144. Describes numerous applications of Spencer Vacuum, which removes, lifts and sorts metals, lint, liquids, etc. (154)

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BY EDWARD A JOSEPH
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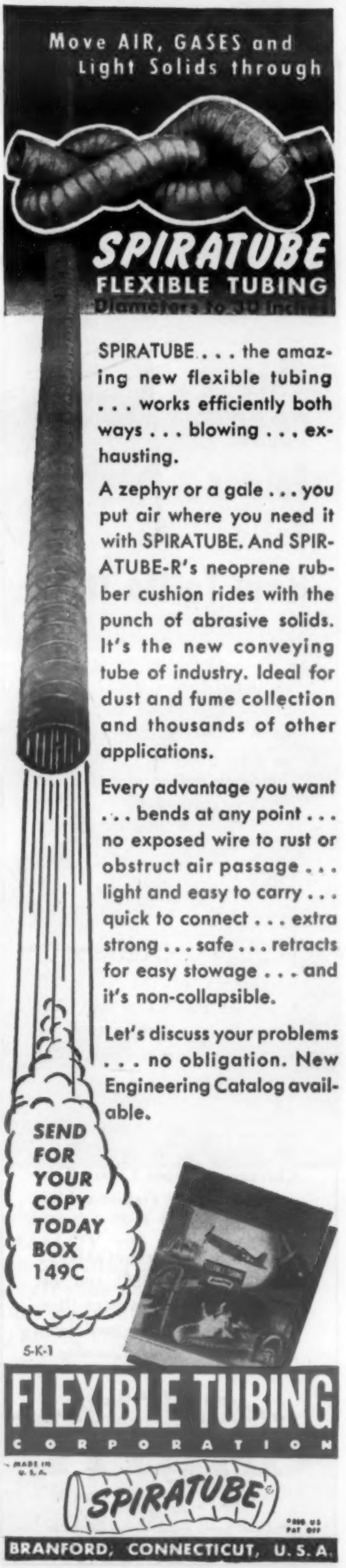
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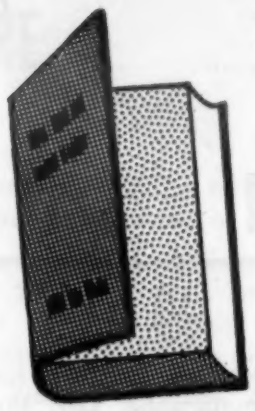

BOOK REVIEWS

Stress Analysis

AN INTRODUCTION TO EXPERIMENTAL STRESS ANALYSIS. *By George Hamor Lee. Published by John Wiley & Sons, Inc., New York 16, N. Y., 1950. Cloth, 6¼ by 9¼ in., 319 pages. Price $5.50.*

This book presents the theory, instrumentation and basic techniques involved in the most commonly used methods of stress analysis.

Believing that a student of experimental elasticity should first be well grounded in the theory of elasticity, the author devotes his first chapter to a review of these fundamentals. He then considers the determination of stresses from strain measurements, developing the equations for the rectangular strain rosettes and offering graphical methods for their rapid solution. The concept of structural similarity is also explained.

With this as background, the author devotes the rest of the text to the instruments and methods employed in experimental stress analysis. He covers the various mechanical and electrical strain gages, and devotes one chapter entirely to the resistance wire strain gage. Two chapters are concerned with the photo-elastic method. Other parts deal with the brittle lacquer method, the membrane and electrical analogies, the Begg's deformeter, and certain miscellaneous methods.

The last chapter includes a section on the evaluation of experimental errors and the cumulative errors obtained through computational operations.

High Temperature Materials

METALS AT HIGH TEMPERATURES. *By Frances H. Clark. Published by Reinhold Publishing Corp., New York 18, N. Y., 1950. Cloth, 6½ by 9¼ in., 372 pages. Price $7.00.*

Ever since World War II engaged metallurgical interest in the gas turbine, data on the properties of metals at elevated temperatures have been forthcoming at a rapid rate. These data have now been assembled and organized by the author, a noted woman metallurgist, into the first American book on high temperature metallurgy.

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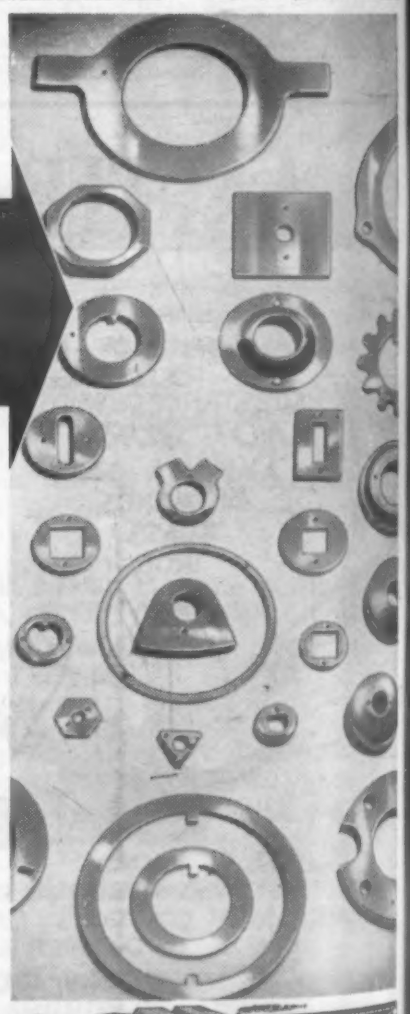

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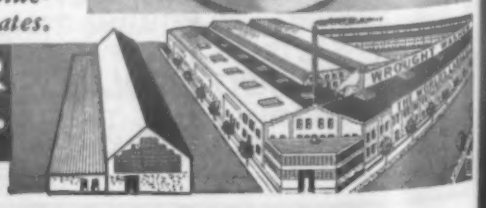

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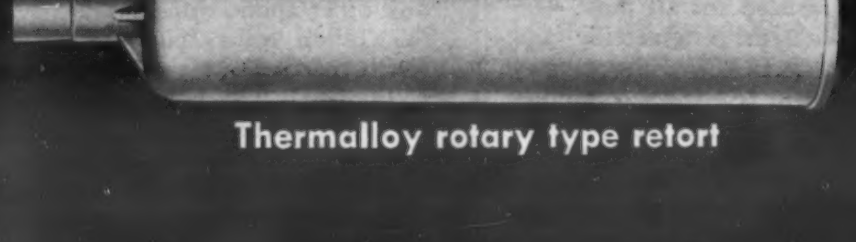

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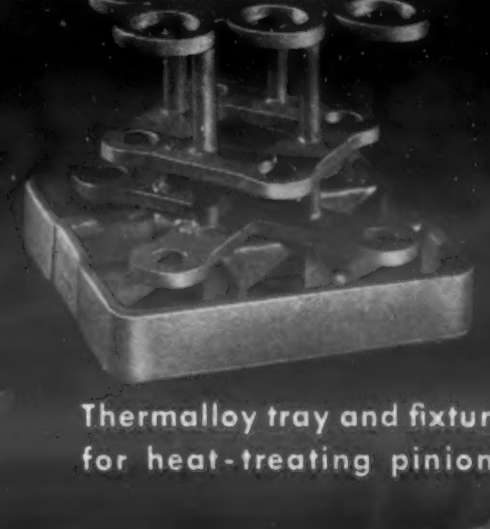

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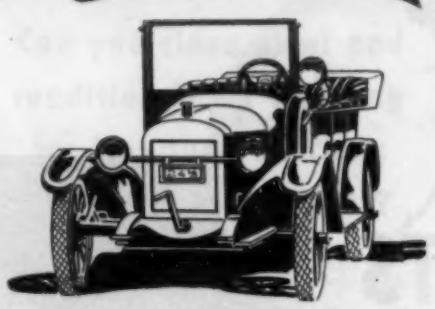

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Book Reviews

continued

book includes data on other metals such as aluminum, lead and magnesium alloys. The text is introduced by a chapter on the phenomenological aspects of plastic flow which surveys the theoretical attempts to discover the laws covering plastic behavior, and includes an extensive discussion of elasticity and viscoelasticity.

There is a vast amount of essential tabular data giving the properties of all the latest alloys which have been developed for service at extremely high temperatures. Full consideration is devoted to the phenomenon of creep in metals and alloys, accompanied by relevant data on this important property. In addition, there is an extensive section on test methods for metals at high temperature and current manufacturing methods for heat resistant alloys.

The book is intended for all those who are concerned with the engineering and metallurgical aspects of high temperature service, particularly in reference to turbojet airplane engines where high temperature alloys play a critical role. Numerous other high temperature demands are being made upon alloys under the nation's new defense program for such weapons as rockets, projectors and high velocity gun barrels.

All metallurgists and mechanical and materials engineers should find this text an abundant source of valuable reference information.

Other New Books

Symposium on Testing of Cast Iron with SR-4 Type of Gage. *Published by the American Society for Testing Materials, Philadelphia 3, Pa., 1950. Paper, 6 by 9 in., 96 pages. Price $1.65.* The papers and discussions included in this Symposium, Special Technical Publication No. 97, were presented at the eighth and ninth sessions of the annual meeting of the American Society for Testing Materials, held in Atlantic City, June 29, 1949.

Symposium on Effects of Low Temperatures on the Properties of Materials. *Published by the American Society for Testing Materials, Philadelphia 3, Pa., 1950. Paper, 6 by 9 in., 68 pages. Price $1.50.* This Symposium was originally presented at a meeting of the Philadelphia District of the American Society for Testing Materials in March 1946, and reviewed by the authors in October 1949. Identified as Special Technical Publication No. 78, this booklet covers specifically the fields of both ferrous and nonferrous metals, plastics and rubbers.

A.S.T.M. Specifications for Steel Piping Materials. *Prepared by the A.S.T.M. Committee A-1 on Steel. Published by the American Society for Testing Materials, Philadelphia 3, Pa., 1950. Paper, 6 by 9 in., 328 pages. Price $3.00.* This latest compilation of A.S.T.M. Standards on steel piping materials, as of December 1949, includes some 50 widely used specifications.

A.S.T.M. Standards on Adhesives. *Sponsored by the A.S.T.M. Committee D-14 on Adhesives. Published by the American Society for Testing Materials, Philadelphia 3, Pa., 1950. Paper, 6 by 9 in., 60 pages. Price $1.25.* The second compilation of A.S.T.M. Standards on adhesives, issued January 1950, contains in convenient form all 15 A.S.T.M. standards relating to this field.

Metallurgical Applications of the Electron Microscope. *Published by the Institute of Metals, London, England, 1950. Cloth, 5¾ by 8¾ in., 164 pages. Price $3.50.* Discussions of 13 papers on the use of the electron microscope in metallurgy, presented at a symposium held at the Royal Institute in London on Nov. 16, 1949, are included in this Monograph and Report Series No. 8.

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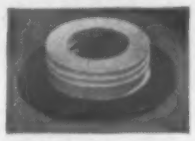

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